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Natural resource accounting in the Yamuna sub-basin

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Contents

Summary

Natural resource accounting in the Yamuna sub-basin was sponsored by the Ministry of Environment and Forests. Several institutes collaborated in this study.

The Yamuna sub-basin consists of Delhi, almost the whole of Haryana, a very small part of Himachal Pradesh, a thin north-eastern section of Rajasthan, and a thin western section of Uttar Pradesh.

TERI's task consisted of the following sections: (1) the impacts of agricultural activities on soil, (2) mineral resource accounts, (3) exposures to air pollution and health, and (4) energy and emissions accounts

The impacts of agricultural activities on soil

The objectives were to examine different agricultural activities, assess their impact on the soil resource, and develop physical accounts for soil degradation.

Information on agricultural activities and soil properties was collected for the study area, and cause and effect were related. Soil degradation was quantified using GIS based analysis.

The Green Revolution technology has penetrated widely in the Yamuna river sub-basin. The gross irrigated area has increased by 1.5 times and the net irrigated area has increased by almost 50 percent during the last 22 years. The consumption of fertilizers has increased by 600% in 22 years since 1970/71, and that of pesticides by 160 percent in 12 years since 1985. Though these measures have helped in increasing agricultural production, the adverse effects of inefficiently managed agricultural inputs are causing concern.

The study area is irrigated with both surface and groundwater sources. In north-western parts of the study area (mostly north-west and central parts of Haryana) nearly 66% of the groundwater is brackish and unfit for irrigation. Therefore, this region is heavily dependent on the surface irrigation systems. Lack of groundwater exploitation and addition of water through canal irrigation and floods in the absence of drainage facilities have led to rising watertables, resulting in waterlogging. This waterlogged condition has led to soil salinity which is further aggravated by impeded drainage, topography, high salt content in the parent material of soil, poor quality groundwater and above all arid and semi-arid climatic conditions.

Higher water tables apart from affecting agricultural crops have many other ill effects, for example reduced moisture storage capacity of soil. The loss in moisture storage capacity can induce floods even when there is light rain. Despite low rainfall, flooding has become frequent in the study area, especially in parts of Haryana.

Another problem of a quite different nature is experienced in good quality groundwater zones. Here, over exploitation of groundwater for rice-wheat based crop rotation is taking place. As a result, the water tables are declining. Nearly seventy % of the districts (including Delhi) are affected by falling water tables. The annual decline in groundwater table ranges from 2 cm in Yamunanagar to 54 cm in Mahendragarh.

Sewage water is most often disposed of by using it for irrigation, which has adverse effects on human health. The application of nitrogenous fertilizers in greater proportions has lead to nitrate pollution of soil and groundwater. The accumulation of nitrates in the soil in excess of crop requirements has a number of implications. The first and most obvious is the leakage of nitrate into the drainage system and hence to drinking water. The nitrate produced in agricultural soils (non-point sources) is transported to surface water bodies where it contributes to eutrophication. The consumption of nitrate rich food, vegetables, and water results in health disorders in humans. Apart from nitrate toxicity, pesticide residues and heavy metals have been detected in plant and animal and human tissues. Blood and milk samples of humans have tested positive for pesticide toxicity in various parts of the study area.

The crop management and agronomic practices have a significant influence on the soil. In the Yamuna sub-basin, since the area under forests is very low (around 2 %), agricultural cropping practices determine vegetation cover (which protects the soil from rainfall). Of the total area under cereals almost 70 % is occupied by just two crops, rice and wheat, which are mostly grown under irrigated conditions, making the study region highly susceptible to wind and water erosion. It is estimated that an area of 3.75 million hectares is affected by soil erosion.

Table 1. Estimated loss in production of rice, wheat and sugarcane in the study area due to soil degradation (thousand tonnes/year)
[these are indicative results only, please see table 6.2 on p.44 for the complete table]

Crops	*Erosion*	*Salinity*	*Waterlogging*	*Waterlogging and salinity*	*Total loss*
Rice	99 8	55.1	14 0	5.4	174.4
Wheat	835 4	270.6	80.6	22 8	1209.4
Sugarcane	2741 7	631 1	33.9	220.8	3627.6

All these problems have resulted in a significant decline in the agricultural production in the region (Table 1). It is estimated that the annual loss of agricultural production is 6 million tonnes, 7% of the total food grain production of the region. Sugarcane and wheat are the two most seriously affected crops. It is estimated that intensive cultivation and erosion of soil result in an annual loss of 8.52 million tonnes of nutrients every year. .

Unsuitable crop management and agronomic practices have contributed to the problem of soil erosion which has resulted in not only in reduced productive capacity of soils but also the loss of valuable plant nutrients from the soil.

Minerals

The objectives were to prepare the physical and monetary accounts for 13 minerals. The monetary accounts required estimating the economic value of depreciation of the mineral resources.

The net price method and the user cost approach have been used for valuing the depletion of minerals in this study. An illustration of the present value method is also presented for rock phosphate, quartz, and feldspar.

The depletion values for some minerals using the net price method and the user cost approach are presented below for the period 1985-90 (Table 2).

The user cost is significantly lower than the depreciation calculated using the net price method. An important factor responsible for the low value of user cost are the long lifetimes of the reserves. For feldspar the user cost is relatively high – Rs 548 000 for 1989 or 57% of the depreciation calculated using the net price method. The remaining 43% of the total net

receipts (depreciation using net price) would represent the true income component under the user cost approach. The lifetime of feldspar reserves estimated for 1989 is 15 years. The user cost for baryte and dolomite is zero throughout the period. On an average, the lifetime of baryte reserves over 1985-90 is 250 years and that of dolomite is as high as 21 135 years in 1989. In case of rock phosphate, the magnitude of user cost is quite low. In 1985 the user cost was Rs 23, a minuscule percentage of the depreciation calculated using the net price method. Similarly in 1990, the user cost is 0.01% of the net receipts. The lifetime of rockphosphate reserves estimated in 1990 is 140 years.

Table 2. Depletion values for some minerals using the net price method and the user cost method (Rs thousand for net price and Rs for user cost)

Minerals	1985		1986		1987	
	Net price	User cost	Net price	User cost	Net price	User cost
Baryte	933	0	702	0	477	0
Calcite	504	227	508	256	510	288
Feldspar	40	1000	168	7000	172	31000
Iron-ore	72	0	78	5	336	91
China clay	35776	0	32032	0	56544	0
Rock phosphate	21600	23	30628	908	74528	6127
Dolomite	534	0	461	0	344	0
Talc	3259	1	3481	2	2401	0

table 2. continued.

Minerals	1988		1989		1990	
	Net price	User cost	Net price	User cost	Net price	User cost
Baryte	669	0	840	0	894	0
Calcite	606	383	606	429	1050	8996
Feldspar	370	52000	968	548000	219	6000
Iron-ore	252	14	1188	184	1517	1
China clay	41004	0	92323	0	983	0
Rock phosphate	77131	7102	109900	14216	104804	14
Dolomite	173	0	246	0	247	0
Talc	1681	0	4356	19	4761	0

Air pollution exposures and health

The objective of the project was to assess the exposure to and health impacts of air pollution in the Yamuna river sub-basin.

A primary survey of 1100 households was conducted in Delhi to gather information on fuel use, time budget of family members, smoking habits, and expenditure incurred on various ailments and diseases.

Table 3. Measured concentration of respirable suspended particulates (RSP) while commuting in Delhi
[the results are only indicative; please see table 15.6, p 120]

	Respirable suspended particulates (grams per cubic metre)		
Vehicle	*Number of observations*	*Mean*	*Standard deviation*
Three-wheeler	9	810	143
Bus	9	803	213
Car	9	373	71
Two-wheeler	9	2858	1467

Air pollution measurements were carried out in Delhi for RSP and CO for such micro-environments as indoor cooking, indoor non-cooking, sleeping, office, shops, schools hours, commuting hours (table 3).

The district population was divided into 24 sub-groups based on rural-urban; nature of work: primary, secondary, tertiary; infant; housewife; student; older and unemployed youth. The daily integrated exposures for RSP (mg-day/m^3) and CO (ppm-day) were calculated based on time budget and air quality levels for all population sub-groups. The population exposures for calculating burden on various population sub-groups for RSP (person-mg-day/m^3) and CO (person-ppm-day) were also computed.

The data on air quality and time-budget were then utilized for other districts in the Yamuna sub-basin (other than Delhi) and first cut estimates were made of daily integrated exposure and population exposure.

Time series secondary data collected from various agencies on air pollution related ailments/diseases have also been collated district-wise in this report.

Energy and emission accounts

The objectives were to estimate at the district level, accounts for energy consumption and emissions of air pollutants. The pollutants considered were particulate matter (SPM), carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (No_x), sulphur dioxide (SO_2), and lead (Pb). The sectors for which the energy and emissions accounts were estimated were power, domestic, transport, and industry (only three industries (fertilizer, cement and sugar) for

which plant-wise production data were available).

The first step was to make an inventory of different sources: transport, industry, domestic and power. Then energy consumption by each of these sources was estimated (Table 4) and emission factors were applied to estimate emissions (Table 5). If these sources had pollution control devices, then the efficiency of the pollution control device was taken into account

Table 4. Estimated energy consumption in the domestic sector in Panipat district (thousand tonnes/year): 1993/94
[the results are only indicative; for more complete results please see chapter 22]

Fuel	Domestic rural	Domestic urban
Wood	110	20
Dung	385	22
LPG	424	4

Table 5. Estimated emissions of criteria pollutants in Panipat from the transport, domestic and power sectors (tonnes/year): 1993/94
[the results are only indicative; for more complete results please see chapter 23]

Pollutant	Transport	Domestic	Power
CO	3,203	9,391	1,780
HC	1,305		890
NO_x	1,781	22	4,700
SO_2	183		14,777
SPM	268	1,381	28,486
Pb	1		

Note. the different pollutants differ in their toxicity; also, emissions from the domestic sector are far more likely than emissions from the transport sector which in turn are more likely than emissions from the power sector to reach a human's breathing zone.

The emission accounts are the logical starting point for the evaluation of abatement options. The data availability varies across sectors, being very good for the power sector, good for the domestic and transport sectors, and being very poor for the industry sector. Future exercises may use selective primary surveys to help fill critical data gaps.

SECTION 1

Impact of agricultural activities on soil resources

G K Girisha and Bhujanga Rao

CHAPTER 1

Introduction

The rise in population has necessitated an increase in agricultural production to meet the growing demand for food, fodder and fibre. Agricultural production has increased many-fold through the use of improved crop varieties, expansion of irrigation facilities, increased use of fertilizers and pesticides. Though these measures have helped in increasing agricultural production, adverse effects of inefficiently managed agricultural inputs are becoming a matter of great concern. There are indications of environmental degradation such as poor soil fertility, incidences of soil salinity, pollution of groundwater, and damage to the physical structure of the soil in the intensively cultivated area

The impacts of agricultural activities can be classified into two categories, extensive impact and intensive impact. The extensive impact results from extending cultivation to areas covered under forests and other biomass. Extension of agricutlure has significantly eroded the environmentally indispensable forests. In India forests are fast being converted into farmlands and areas covered under the river valley projects are predominately oriented to bring more and more area under irrigated farming. The intensive impacts are due to farming in the existing arable lands through increased use of such farm chemicals as biocidal material, fertilizers, etc. The contamination of groundwater by nitrate due to application of nitrogenous fertilizers, accumulation of dangerous levels of pesticides, particularly the organochlorines, in terrestrial and aquatic food chain are the manifestations of intensive farming.

This study has been attempted to analyze the impacts of agriculture on the soil resources in the yamuna river sub-basin. This paper is divided into seven chapters. The first chapter is the introduction, chapter 2 deals with the methodology, chapter 3 is a description of the study area, chapter 4 is a review of the agricultural practices in the region, followed by a discussion on the impact of these practices on soil in chapter 5, chapter 6 deals with the development of physical accounts for soil degradation in the study area, and finally chapter 7 is the conclusion.

Objectives

- To carry out detailed analysis of agricultural activities in the study area.
- To assess the impacts of agricultural activities on soil resources in the study area.
- To develop physical accounts of soil degradation in the study area.

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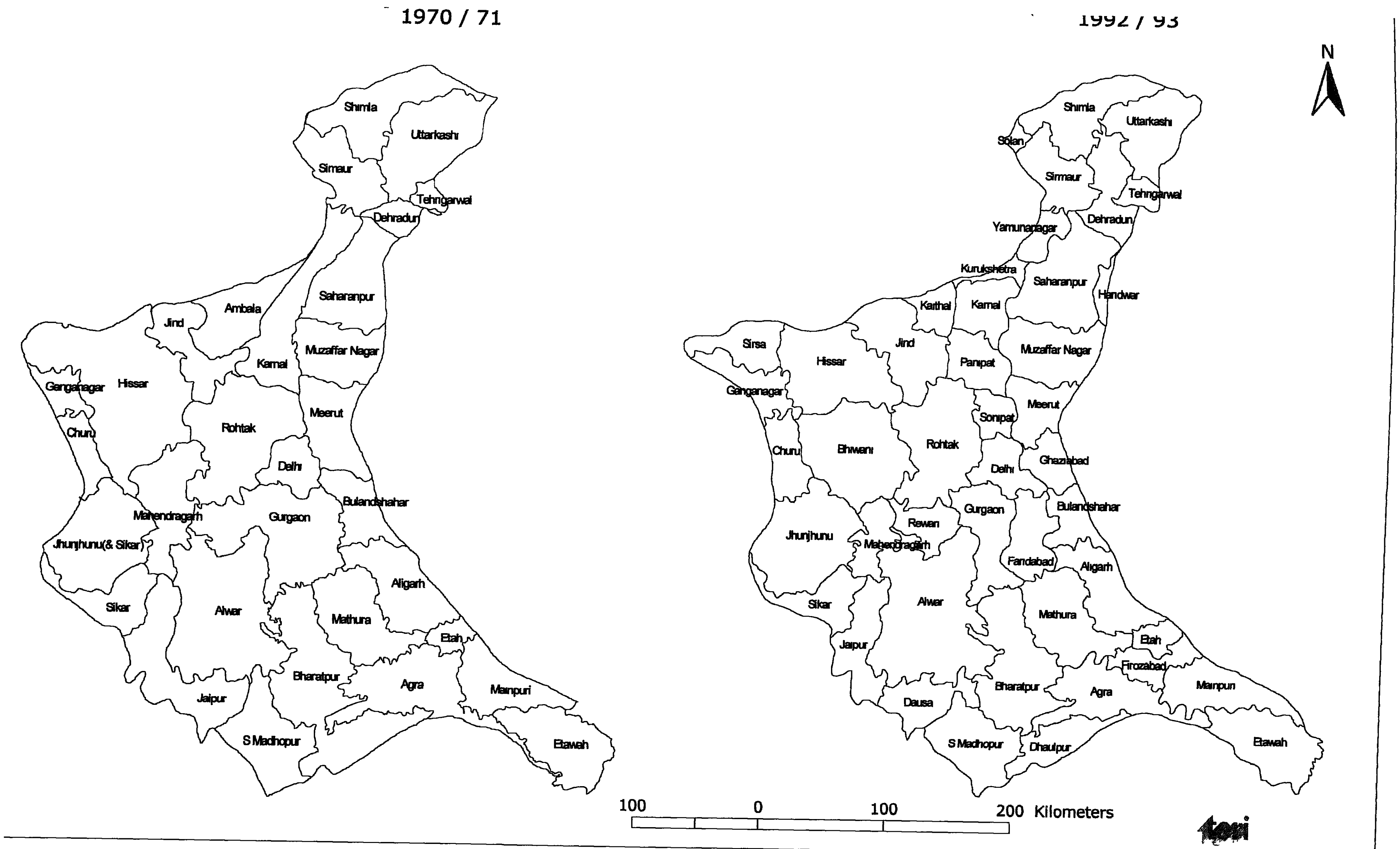

Figure 2.1 Study area: The Yamuna river sub-basin

CHAPTER 2

Methodology

The study area has a natural boundary. The information on agricultural practices and natural resources is documented for the administration boundary, mostly at a district level. Information on some of the parameters, pesticide consumption for example is available at the state level. Over time larger districts have been divided into smaller districts(figure 1.1), but there is no information on agricultural parameters for these districts. For example, district Shikohabad was formed out of (presumably) Mainpuri district, but there is no data available on the agricultural parameters for Shikohabad in the official statistics.

Another problem we encountered was the exact location of the study area because of lack of an accurate base map of the study area. Without an accurate base map proper analysis of spatial information by using Geographic Information System (GIS) was impossible. Therefore the following methodology was adopted to overcome these constraints.

The study area: The watershed atlas (AISLUS 1988) prepared by the survey of India was used to delineate the study area boundary. In this atlas, the Yamuna river-sub basin is shown as a part of the Ganga river basin and according to this map *the study area* includes not only *Yamuna river basin* up to the chambal confluence but also a part of *Ghaggar river basin*. Since this map was prepared in seventies, the study area map derived from this atlas was used to represent the study area in 1970s. Since we did not have an accurate base map the boundary of Etawah district was used as the study area boundary. The map extracted from the Yamuna sub-basin of the Ganga basin map, produced by the Centre for study of Man and Environment(CSME 1982), Calcutta, was used to represent the study area in 1980s. The watershed atlas published by Central Pollution Control Board (CPCB 1994) was used to extract study area map for the 1990s. The list of districts covered by each of these maps is given in table 2.1.

Table 2.1 Districts in the study area over time

1970/71	1980/81	1992/93
Ambala	Ambala	Kurukshetra
Karnal	Kurukshetra	Karnal
Jind	Karnal	Jind
Rohtak	Jind	Sonipat
Gurgaon	Sonipat	Panipat
Mahendragarh	Rohtak	Rohtak
Hissar	Faridabad	Faridabad
Shimla	Gurgaon	Gurgaon
Simaur	Mahendragarh	Mahendragarh
Alwar	Bhiwani	Bhiwani
Bharatpur	Hissar	Hissar
Jaipur	Sirsa	Sirsa
Jhunjhunu(& Sikar)	Shimla	Rewari
S Madhopur	Simaur	Kaithal
Sikar	Solan	Yamunanagar
Churu	Alwar	Shimla
Ganganagar	Bharatpur	Simaur
Agra	Jaipur	Solan
Aligarh	Jhunjhunu(& Sikar)	Alwar
Bulandshahar	S Madhopur	Bharatpur
Dehradun	Sikar	Jaipur
Etawah	Churu	Jhunjhunu
Mathura	Ganganagar	S Madhopur
Meerut	Agra	Sikar
Muzaffar Nagar	Aligarh	Dhaulpur
Saharanpur	Bulandshahar	Dausa
Uttarkashi	Dehradun	Churu
Tehrigarwal	Etawah	Ganganagar
Etah	Ghaziabad	Agra
Mainpuri	Mathura	Aligarh
Delhi	Meerut	Bulandshahar
	Muzaffar Nagar	Dehradun
	Saharanpur	Etawah
	Uttarkashi	Ghaziabad
	Tehrigarwal	Mathura
	Etah	Meerut
	Mainpuri	Muzaffar Nagar
	Delhi	Saharanpur
		Uttarkashi
		Haridwar
		Firozabad
		Tehrigarwal
		Etah
		Mainpuri
		Delhi

Data: Another major problem encountered was the data. Information on most of the agricultural parameters is available for an administration boundary. Therefore the information on parameters

of agricultural practices and degradation of soil have been collected and analyzed at administration boundary level (mostly at a district level).

Assessing the impact of agriculture: The study area is large, hence it was decided to carry out the study primarily by using the information generated by the various institutions working on the different aspects of agriculture and environment in the study area. Therefore, the TERI team visited research institutions (list is provided in table 2.2) to collect information on various parameters. After all these visits the team realized that not much work has been carried out to document the impact of agriculture as an activity on soil resource. Absence of official information made us look for the next best alternative source, research papers published in scientific journals. Therefore, extensive survey of literature was carried out to document the ill effects of agricultural activities on the environment. Here also we were disappointed. In the past ten years hardly a few papers have been brought out on the impact of intensive agriculture on environment. Of these only few papers were relevant to the study area. Thus, even an extensive survey of literature could not give us a complete picture of the problem.

Table 2.2. List of institutes visited by the TERI team

Information	*Institutes*
Agricultural parameters	Directorate of Economics and Statistics, New Delhi Indian Agricultural Research Institute, New Delhi National Dairy Research Institute, Karnal Haryana Agricultural University, Hisar.
Irrigation	Central Groundwater Board, New Delhi Ministry of Water Resources, New Delhi
Fertilizer related statistics	Fertilizer Association of India, New Delhi
Pesticide consumption	Pesticide Association of India, New Delhi
Irrigation water quality	Central Soil Salinity Research Institute, Karnal
Soil Salinity and waterlogging	Central Soil Salinity Research Institute, Karnal
Soil Erosion	Central Soil and water Research and Training Institute, Denra Dun
Spatial distribution of soil degradation problems	National Bureau of Soil Survey and Land Use Planning, Nagpur and Delhi Indian Institute of Remote Sensing, Dehra Dun National Informatics Centre, New Delhi
Libraries visited	Indian Council of Agricultural Research, Indian Agricultural Research Institute, Ministry of Agriculture, Planning Commission, World Bank, Food and Agriculture Organization, National Dairy Research Institute, Central Soil Salinity Research Institute, Haryana Agriculture University, Central Statistical Organization, Fertilizer Association of India etc.

The National Bureau of Soil Survey and Land Use Planning, Nagpur, has published information on the spatial distribution of soil degradation types at national level at four million scale (Sehgal and Abrol 1994). The TERI team visited the National Bureau of Soil Survey and

Land Use Planning (NBSS & LUP), Nagpur, to collect information on soil degradation in the study area. Here again the TERI team was disappointed, there was no information on the soil degradation at the district level. Later it was learnt that state level information on soil degradation is available for some states but all were in press. The TERI team is in touch with the NBSS & LUP but till July 1997 nothing has been brought out on the study area. Therefore in the absence of the information at a district level, we used the soil degradation map of India to estimate area under degradation in the study area by using the Geographic Information System (GIS).

There exists a relation between type of intensive agricultural activity and the possible impact it can have on the soil. In this study these relationships were utilized as a basis to frame the arguments. The various relations between the intensive agriculture activities and the impact can be represented in form of cause and effect. These relationships are given in figure 2.1. As the area under forest has remained more or less constant at two percent of the total geographical area since 1970s, the extensive impact of agricultural activities was not considered in the present study.

Agricultural activities	Process of degradation	Impact on soil
Irrigation	Waterlogging	Physical degradation
	Accumulation of salts	Chemical degradation
	Leaching of organic matter/nutrients	Chemical degradation
	Decline in watertable	Physical degradation
Fertilizer application	Nitrate toxicity	Chemical degradation
	Heavy metal toxicity	Chemical degradation
	Deterioration of physical properties	Physical degradation
	Fertilizer induced alkalinity/acidity	Chemical degradation
Crop management	Nutrient removal	Physical and Chemical degradation
	Erosion of soil	
Pesticide application	Pollution of soil	Chemical & Biological degradation

Figure 2.1. Relationship between agricultural activities and soil degradation

Developing physical accounts . The estimation of the physical impact of soil degradation, due to faulty agricultural practices, has been done based on yield reduction factors. The National Bureau of Soil Survey and Land Use Planning, Nagpur, has given information on the spatial distribution of severity classes for each type of soil degradation at the national level. These severity classes are the indicators of reduction in the productive capacity of the soil.

The severity of degradation can be viewed as low, medium, high and extreme. Each severity class is associated with a certain level of decline in productivity of soil. The severity

values for each type of soil degradation reported in the study area and the average yield of crops were used to estimate the loss in agriculture production. The different steps involved can be written as:

1. Estimation of area under different types of soil degradation

2. Estimation of agricultural area affected by soil degradation by using the information on area under agriculture

3. The total area affected was distributed amongst crops by using the information on the proportion of the area under different crops

4. Collection of information on yield reduction due to degradation based on information on the severity of degradation

5. The degraded area , yield reduction factor and the average yield of the respective crops were multiplied to obtain production loss due to soil degradation

Estimating loss of nutrients due to erosion: Information is available on the average nutrient contents of the soils in the study area. The severity level of soil erosion in the study area gives information on the degree of erosion or the amount of soil lost per hectare of land in a year These two parameters were used to estimate the amount of major nutrients, namely, Nitrogen, Phosphorus and Potassium lost in a year.

Steps involved are:

1. Obtain information on the nutrient content of the soil in the study area

2. Collect information on the degree of degradation or the amount of soil lost per hectare of land in a year.

3. Multiply 1 and 2 to estimate amount of nutrients lost due to erosion

Estimating nutrient removal due to crop growth: The cultivation of high yielding varieties of crops is known to remove a definite amount of nutrients from soils. An exercise was carried out to estimate the amount of major nutrients (Nitrogen, Phosphorus, and Potassium) removed from

the soils by eleven major crops in the study area. Indian Council of Agricultural Research (ICAR) has estimated the amount of nutrients removed from soil by different crops. This information and the area under different crops was used to estimate the nutrient removal from soils. It is possible that this loss can be replenished by the addition of fertilizers to the soil. Therefore, the addition of fertilizers was considered to estimate the net loss of nutrients due to cultivation of crops.

Steps involved :

1. Obtain information on the amount of nutrients removed from soil by different crops

2. Collect information on the area under different crops

3 Estimate the amount of nutrients removed from soil due to crop cultivation by using 1 and 2

4 Subtract 3 from amount of nutrients added through fertilizers to get the net removal of nutrients from soil due to agriculture

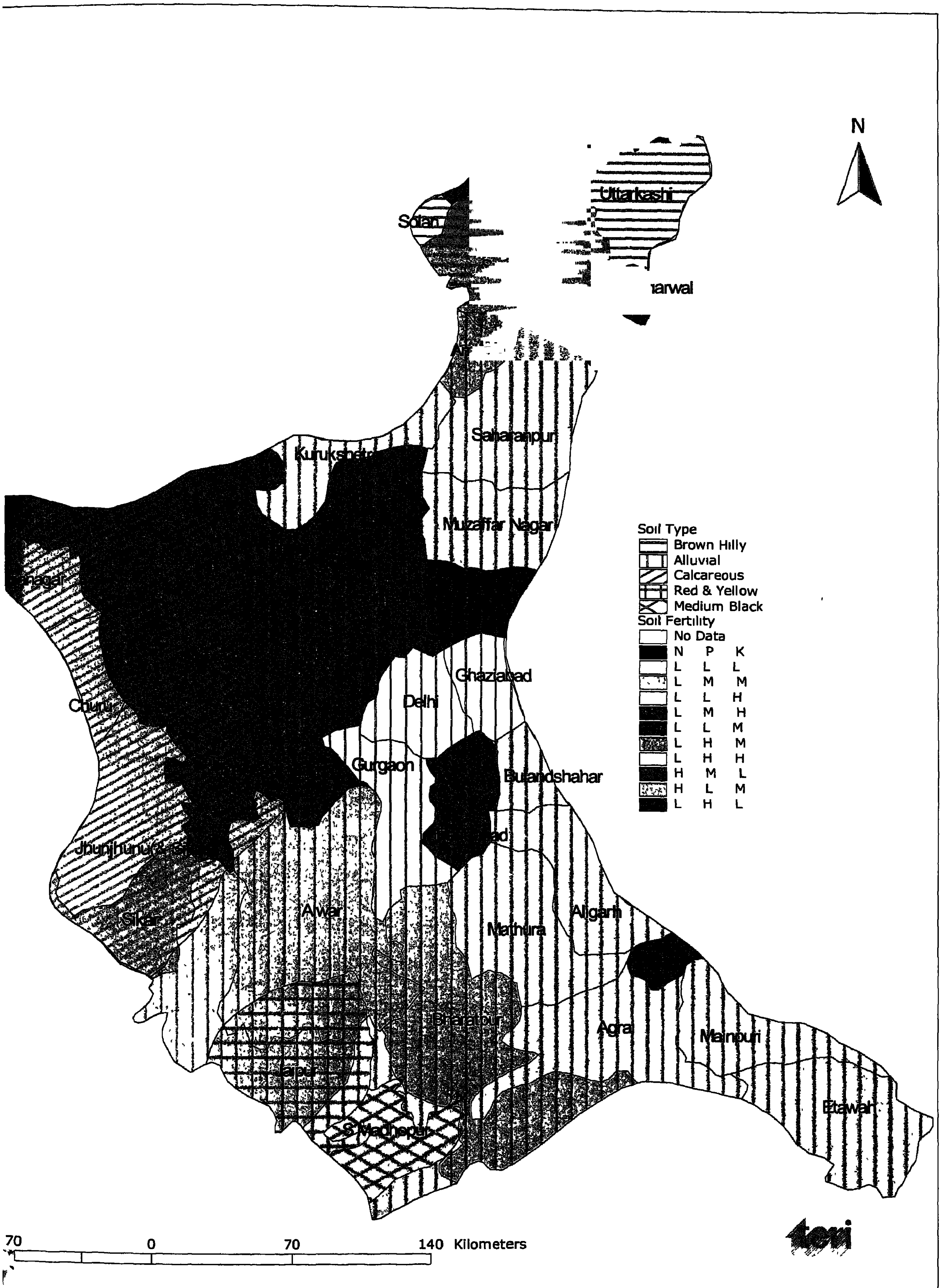

Figure 3.1 Soil type and fertilizer consumption: 1980

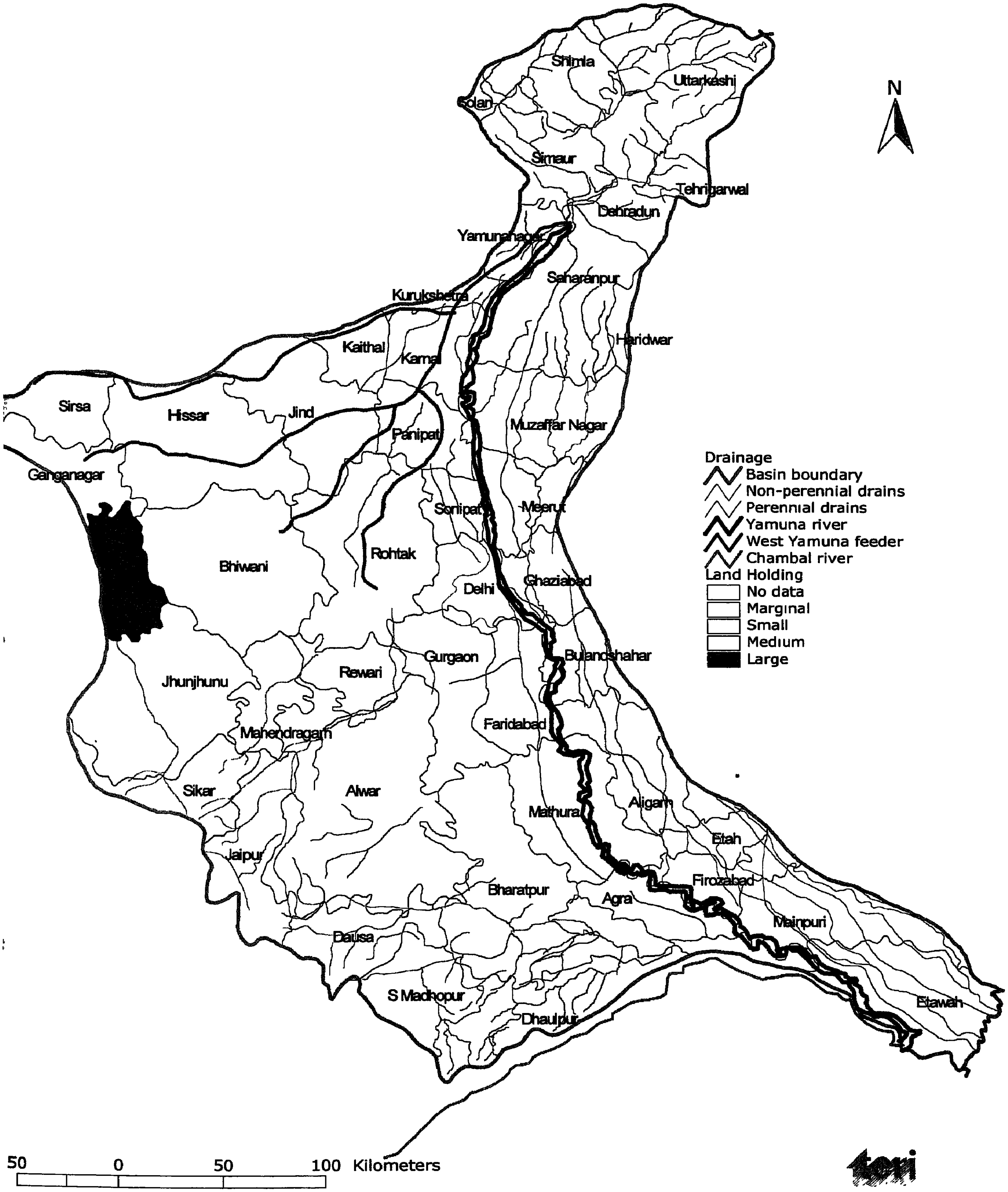

Figure 3.2 Average land holding size in the study area in 1992

CHAPTER 3

The study area

Location

The location of the study area is given in figure 1.1. It includes districts of five states namely Himachal Pradesh, Haryana, Uttar Pradesh, Rajasthan and Delhi. The study area is situated between 26°18' and 31° 30' North latitudes and 75°12' and 79°24' East longitude. It occupies approximately an area of 11 million hectares[1].

Physiography

The study region represents a variety of landscapes varying from hills in the northern parts to almost level Alluvial plains in the central parts and sand dunes and Vindhyan range in the southern parts. Major part of the study area falls in the Indo-Gangetic alluvial plains. The study area has been divided into four major physiographic regions namely (I) Siwalik hills, (ii) Alluvial plains, (iii) Aravalli Hills and (iv) Aeolian plains. The general slope of the study area is from north to south, but slopes become reverse in south and south-west parts due to subdued ranges of Aravalli hills. A major portion of the study area is drained by Yamuna and Ghaggar rivers and their tributaries.

Climate

The study area has a semi-arid climate. Three distinct vegetational seasons are recognized, a dry hot summer from March to June, a wet monsoon from July to September and a dry cold winter from October to February. The summer months are scorchingly hot with temperature ranging from as high as 49.9°C in Bhiwani to as low as 19°C in Shimla. June is the hottest month. The winters are severe with minimum temperature varying from 6°C in Delhi to 0°C in places like Churu. When temperature drops to freezing point, frost may also occur and cause damage to crops. January is the coldest month of the year. The average rainfall of the region is around 660 mm, and 80% of which is received during July to September. This falls short of annual potential evapo-transpiration[2] demand of 1550 mm.

But throughout this paper the entire area of districts covered under the study area either partly or fully has been used for analysis

The Potential Evapo-Transpiration demand is equal to the amount of water lost from soil through evaporation from soil surface and transpiration from plant surface when the moisture supply to soil is unlimited.

Geology and soils

The geologic formations belong to Proterozoic to the quaternary ages. The succession of rock formations is recent and sub-recent soils, alluvium, blow sand and nodular limestone, pegmatite and basic intrusive belonging to post-Delhi intrusives, and the Alwar quartizites of the Delhi systems. There are four dominant type of soils namely Brown hilly soils which extends from Shimla to parts of Dehra Dun, Calcareous sierozemic observed mostly in western parts of Haryana and districts of Rajasthan, Red and yellow soils seen in parts of Jaipur, Alwar, and Sawai Madhopur and Alluvial soil which occupies the remaining area of the study region (figure 3.1). The average composition of the soils of the region are presented in table 3.1.

Table 3.1 Physico-chemical properties of soils of the study area

Parameter	*Unit*	*Value*
Texture	Texture class	Sandy to fine loam
pH (1: 2 5)	(1: 2.5) ratio	6.5 - 8 0
Electrical Conductivity	(1:2 5) ratio	0.5 - 1 3
Cation Exchange Capacity	C mol Kg^{-1}	7-13.5
Organic Carbon	%	0 2-1.5
Nitrogen	%	0.05
Phosphorus	%	0.15
Potassium	%	3.48

Source: Das and Chatterjee 1982

Land capability

The land capability of Haryana, Uttar Pradesh and Rajasthan soils range from class I to IV. In Delhi the soils have a capability subclass III c, since a large portion of land is irrigated, most of the soils have class II C capability. Most of the soils in Himachal Pradesh have class II land capability. The land capability classes I to IV are considered to be suitable for the cultivation of field crops. The other limitations for crop production are soil salinity, improper drainage, excessive wetness, waterlogging and erosion hazard.

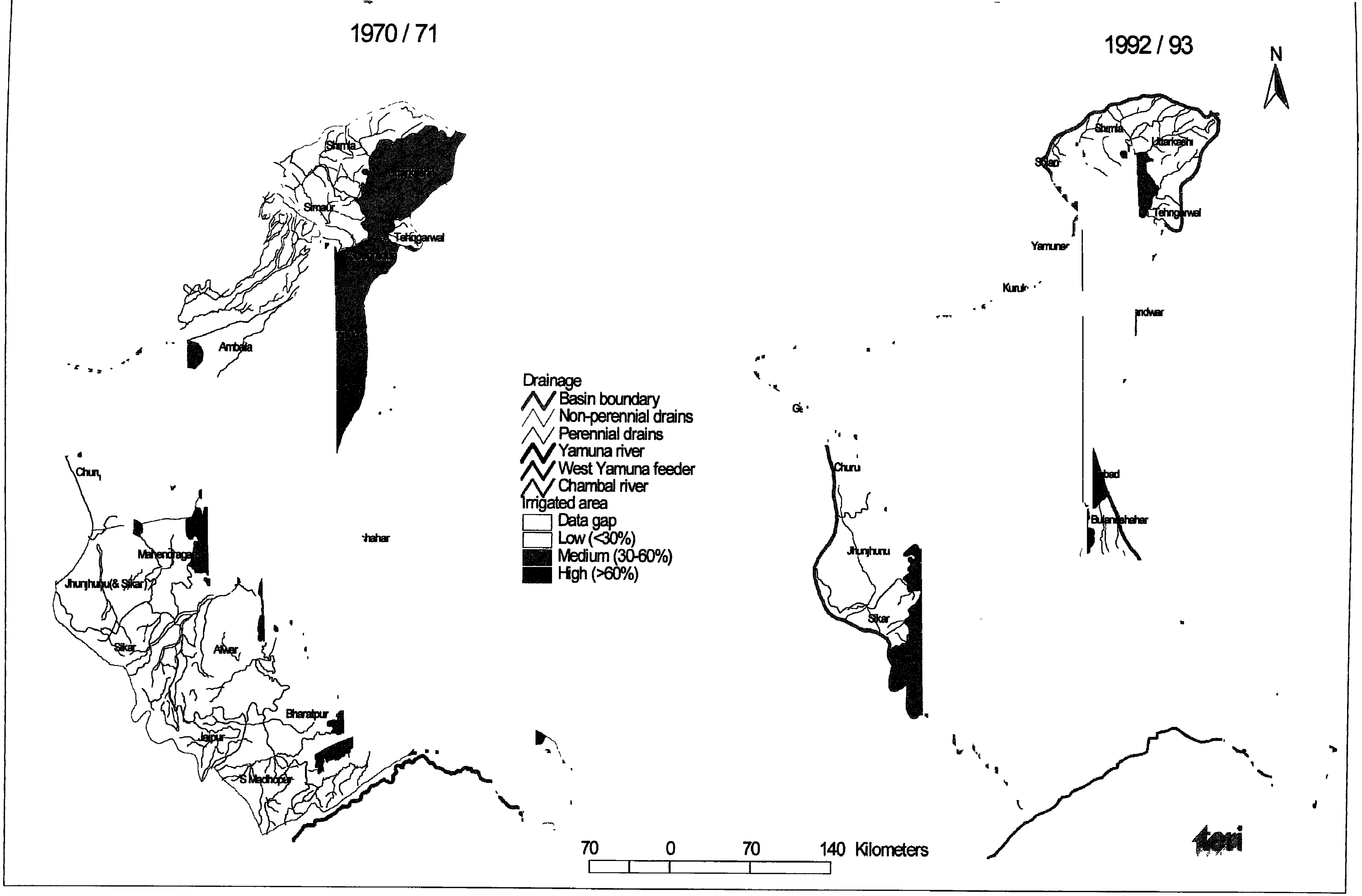

Figure 4.1 Extent of irrigation

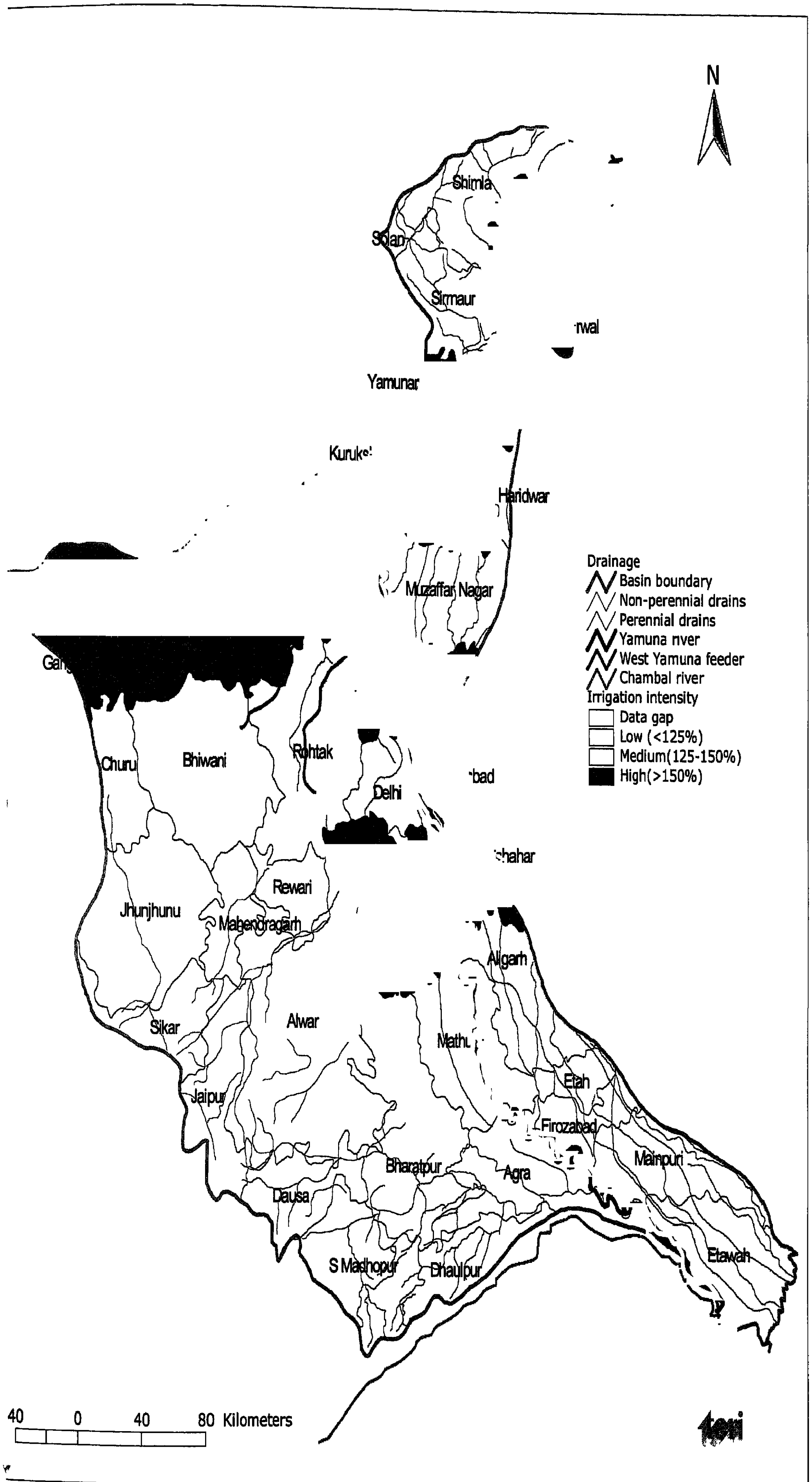

Figure 4.2 Irrigation intensity in 1992

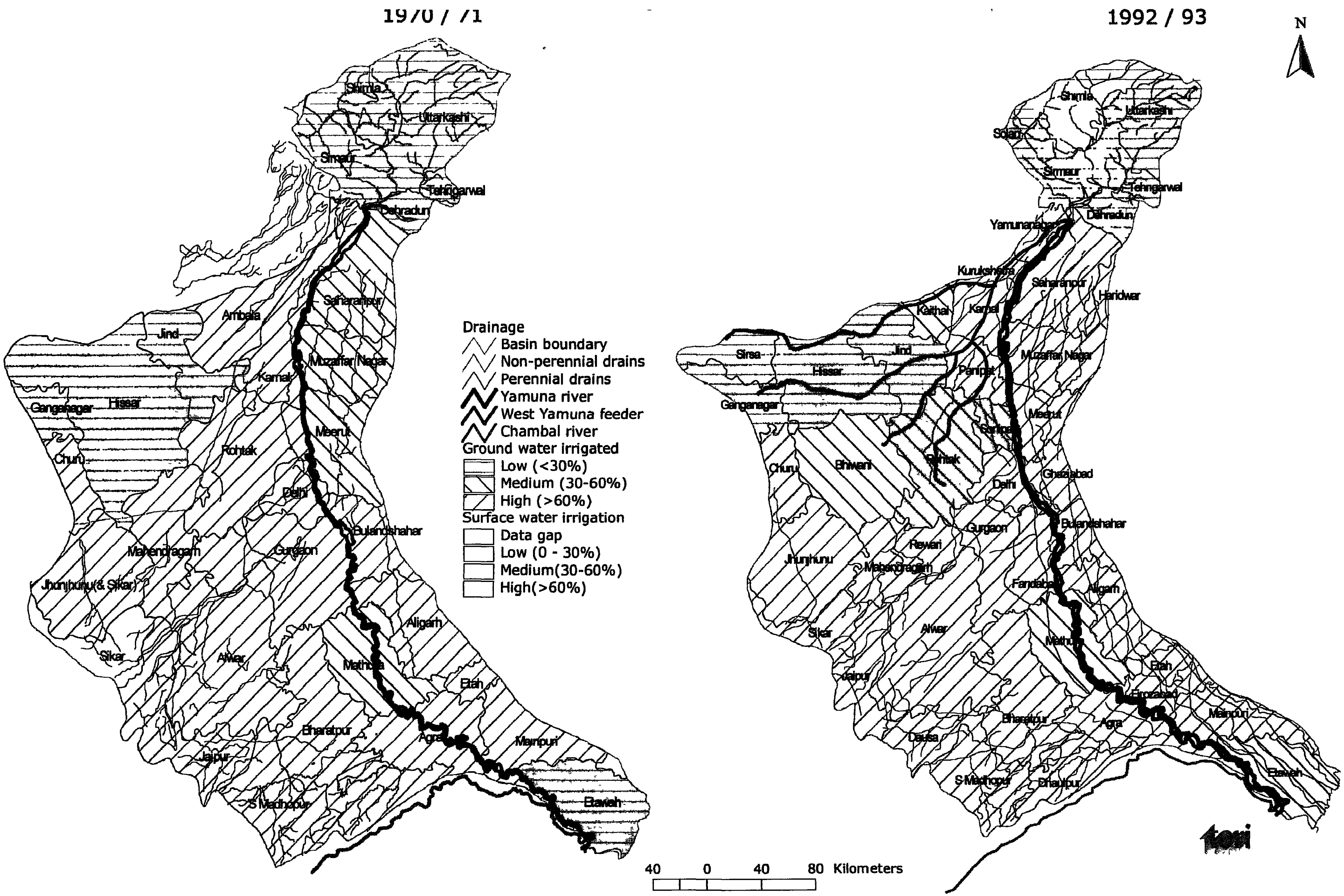

Figure 4.3 Source-wise irrigation

Land use and agriculture

Table 4.1. Land use in Yamuna sub-basin (M ha)

Year	Total	Forest	Non-Agril	Uncultivated	Fallow	Net sown	Gross area	Area under agriculture (%)	Cropping Intensity
1970/71	20.49					13.67	17.32	66.71	126.70
1980/81	20 99	2.18	2.21	1.62	1 54	13.32	17.89	63.45	134.31
1985/86	20 92	2 31	2.18	1 21	1.34	13.59	18.82	64.96	138.48
1989/90	20 95	2.40	2 14	1.44	1 66	13.34	18.61	63.67	139.50
1992/93	20.95	2.30	2.07	0.95	1.35	13.52	19 38	64.53	143.34

Source: Directorate of Economics and Statistics (Various Issues)

The study area has a total population of 77 million, and only 33% of the total population is considered to be the main working population. Of this working force, as high as 63% depend on agriculture for their livelihood. The average land holding size in the study area is 2.43 ha, which falls in the category of medium size. In the entire study area 17% of the districts are having marginal land holding size, 37% small , 41% medium and only 5% of the districts are having large land holding size in 1992/93 (figure 3.2).

Agriculture is the major land use seen in the study region and for whole of the study area, it has more or less remained constant at 66 %. The study area is one of the few regions in India which have witnessed the full success of the green revolution technology. Soon after the introduction of dwarf high yielding varieties of Wheat in early 60s , highest priority was given to improving agricultural production. The measures to encourage modern practices of agriculture included expanding and modernizing the irrigation system in the shortest possible time, providing electricity and paved roads to all villages and institutional developments like creation of marketing and credit facilities for agricultural inputs, subsidized electricity etc. All these efforts have had a visible impact. Though area under agriculture has remained almost constant at 13.5 million hectares during the last twenty two years, the gross cropped area has increased from 17 million hectares to 19 million hectares. The gross irrigated area has increased by 1.5 times and the net irrigated area has increased by almost 50 percent during 1970 to 1992. The consumption of fertilizers has increased by 600% in 22 years since 1970/71. and that of pesticides by 160 percent in 12 years since 1985.

Irrigation

Table 4.2. Irrigated area (in million hectares) by different sources in the study region

Year	Canal	Tank	Groundwater	Others	Net Irrigated	Gross Irrigated
1970	2.526	0.068	2.699	0.094	5.295	-
1980	2.902	0.058	3.717	0.132	6.795	-
1985	2.965	0.008	3.956	0.071	7.011	-
1989	3.062	0.006	4.487	0.079	7.534	11.130
1992	3.121	0.011	4.704	0.085	7.903	11.739

Source: Directorate of Economics and Statistics (Various Issues)

A number of new major and medium irrigation schemes and lift canal irrigation systems were expedited in addition to modernization of old irrigation systems. The installation of augmentation deep tube wells, supplying groundwater to canals, as well as direct irrigation tube wells was launched. In Haryana farmers were provided with financial credits to construct their own tube wells. As a result since 1966 in Haryana alone the number of government owned and operated tube wells has increased fivefold to 3100 and private shallow tube wells twenty fold to touch the number of 5,50,000 in 1995. In Haryana the net irrigated area has doubled from 1.3 million hectares in 1966 to 2.6 million hectares in 1995, this about 70 percent of the net cultivated area. In the whole of the study region the net irrigated area has increased from 5.3 million hectares in 1970/71 to 7.9 million hectares in 1992/93. As it is evident from the irrigation map (figure 4.1) groundwater sources provide most of the irrigation in the study area but in the north-western parts including the districts of Bhiwani, Sirsa, Jind, Hissar, Karnal, Rohtak, Ganganagar, Sonipat and Kaithal, largely depend on canal irrigation (figure 4.2). In districts of Shimla, Simaur, Dehra Dun, Uttarkashi and Tehri Garhwal surface water is the major source of irrigation. In these areas the surface water for irrigation mainly comes from the number of perennial streams flowing through the region.

The creation of irrigation potential in the region has lead to farmers taking more than one irrigated crop in a year. The intensity of irrigation has increased over time, in 1992, the irrigation intensity was 148 % (figure 4.2). These improved irrigation facilities have resulted in an increase in the number of crops taken during a year. This is supported by the fact that in the study area the cropping intensity has increased from 126% in 1970s to 143 % in 1992.

Canal irrigation: In north-western parts of the study area (mostly north-west and central parts of Haryana) nearly 66% of the groundwater is brackish and unfit for irrigation. Therefore, this region is heavily dependent on the surface irrigation systems. There are two distinct sources of surface water for Haryana namely the Bhakra canal system and the Western Yamuna canal

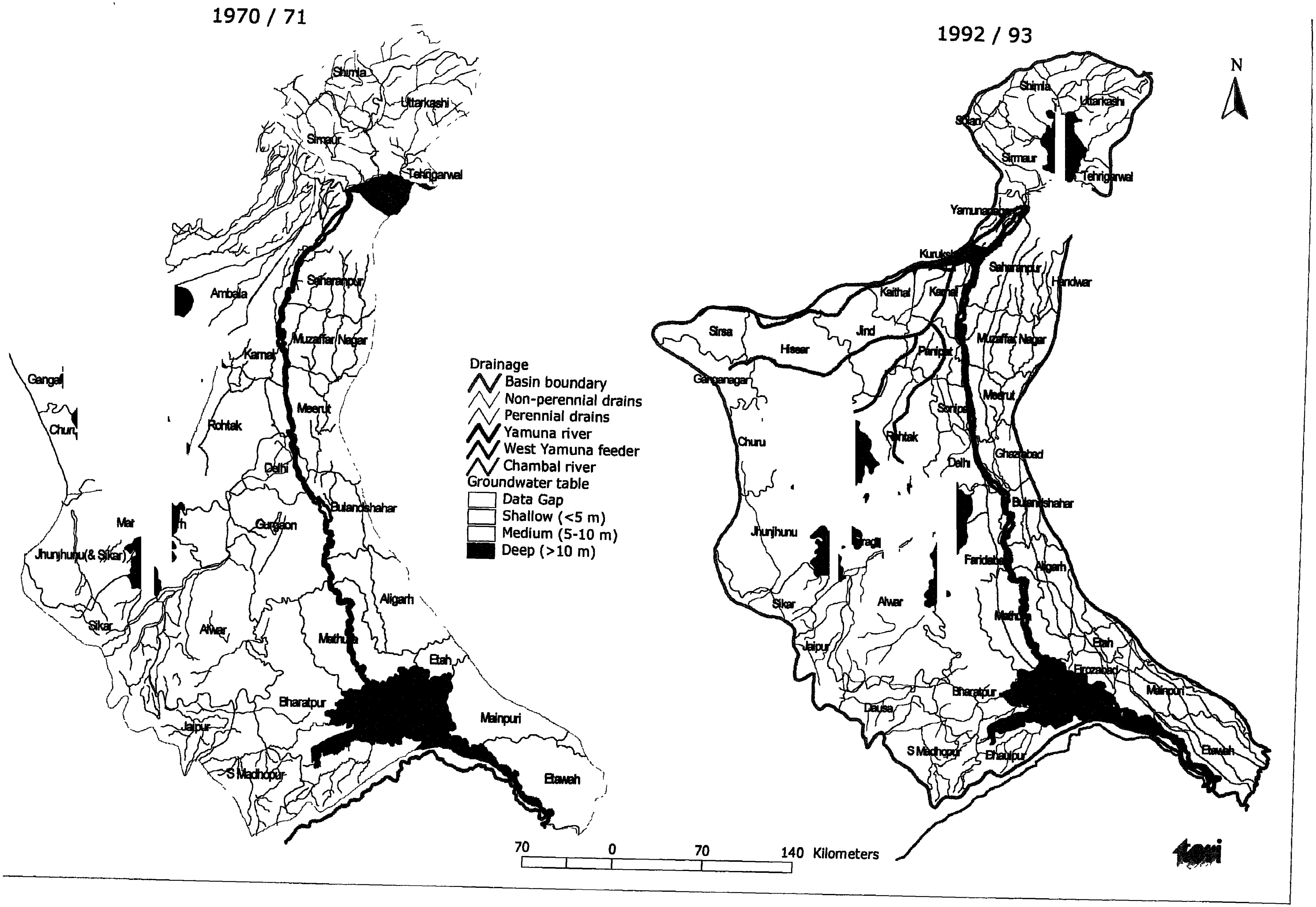

Figure 4.4 Ground water table trend

system. In North western parts of Rajasthan water is supplied through Indira Gandhi Canal system whereas some parts of study area are irrigated by the eastern Yamuna canal systems.

The irrigation water is supplied to farmers by following the classic rotational schedule, also known as the 'warabandi' system. This system is about use of canal water on a rigid rotation schedule of fixed duration and frequency which is generally 24 days. Water is rotated among the branch tributaries of canals for 8 days periods according to priority. If a certain canal branch has first priority during the first 8 days, it will receive full supply of irrigation water. During the second period of 8 days, it will have second priority and receives water, but, depending on the availability, most probably not the full supply. During the third period, it will have the least priority and is scheduled not to receive water, unless the supply to the region is excessive. Because of this system, considerable uncertainty and variability of canal water prevails in the region

The farmer's entitlement of water is proportional to the size of the land holding without consideration of the soil type, crops grown, climatological factors etc It is argued by the government officials in the irrigation department that this system of water distribution according to such rigid schedule ensures higher equity, ease in operations and less management problems. Irrigation water charges to farmers are fixed based on type of crop and area actually irrigated with surface water. As such the charges of irrigation water are very low ranging from Rs.55 to 110 per hectare of irrigated land (based on the discussions with the official in irrigation department) and farmers would pay much less if they irrigate less area. In most of the districts the average land holding size is less than two hectares. It is argued that the uncertainty and variability in distribution of canal water and low cost of canal irrigation water has led to over-irrigation and wasteful use of canal water.

Groundwater irrigation: A major portion of the Yamuna sub-basin is irrigated by groundwater resources In 1992 groundwater sources contributed 68 percent to the net irrigated area. The south-western parts of Yamuna sub-basin consists of upland areas with sand dunes and Aravalli hills and the south-eastern part is having undulating topography and consists of Vindhyan range mountains. This situation makes these parts of the study area unsuitable for gravity irrigation. These areas are chronically water deficient. Therefore to provide protective irrigation to crops lift irrigation schemes have been introduced.

Due to diversion of Yamuna river water by eastern and western Yamuna canals, the north-western regions below Tajewala seldom receive adequate water to irrigate. In a year only during three months these regions receive adequate surface water to irrigate cultivated areas. The rainfall received in these parts is not enough to ensure successful crop growth. Therefore to

undertake agriculture as a profitable venture farmers have installed a number of shallow tube wells to irrigate their fields. Realizing the limitations for extending the canal irrigation system in these regions, the respective governments have created favorable atmosphere for the spread of minor irrigation in these regions. Farmers were provided with financial credits to construct their own tube wells. As a result the number of tube wells has increased many-fold In Haryana state alone since 1966, the number of government operated tube wells has increased fivefold to 3100 and private shallow tube wells twenty fold to touch the number of 5,50,000 in 1995 The groundwater extraction has increased over time. Consequently several districts or blocks in districts have become over-exploited. The exploitation level ranges from 104 % in Delhi to 18 % in Himachal Pradesh. The exploitation levels in Rajasthan and Uttar Pradesh are 51 and 37% respectively (table 4.3).

Though at the state level, the picture looks encouraging to undertake further groundwater exploration activities, the picture is something different at district levels Several districts or the blocks in these districts have become over exploited. In Haryana all the 16 districts have blocks which are over-exploited, i.e., out of a total of 108 blocks 45 are overexploited and 6 blocks are in dark region. In Rajasthan, blocks in the districts of Alwar, Bharatpur, Dholpur, Jaipur, Jhunjhunu, Sawai Madhopur and Sikar are either over-exploited or on the verge of becoming over-exploited. Similarly in Uttar Pradesh districts of Agra, Bulandshahar, Firozabad, Ghaziabad, Mathura, Meerut, Muzaffarnagar, and Saharanpur have over-exploited blocks As a result of this increased pumping of groundwater for irrigation, the water table in these districts is going down (figure 4.4). The annual decline in groundwater table ranges from 2 cm in Yamunanagar to 54 cm in Mahendragarh.

The groundwater irrigation development in the study area is very interesting In south-western parts of the basin the area under groundwater has increased with time but the irrigation intensity has remained low, whereas, in the south-eastern parts of the basin the area under groundwater has remained low (up to 30%) or medium(31 to 60%), but the intensity of irrigation has increased. In eastern and north-eastern parts of the basin both area and intensity has increased.

The efficiency of water utilization in the region was quite low, especially the canal irrigation water. Comparatively groundwater use efficiency (2.13 hectares per 10000 cubic meters) was higher than that of canal irrigation water(1.2 hectares per 10,000 cubic meters).

Table 4.3. Groundwater resource utilization (in million hectare meters per year) in the study area.

State	Total replenishable groundwater resource	Domestic, Industry and Other uses	Available groundwater for irrigation	Utilizable groundwater for irrigation	Gross draft	Net draft
Haryana	0 85	0.13	0.72	0 65	0.87	0.61
Himachal Pradesh	0.04	0.01	0.03	0.03	0.01	0.01
Rajasthan	1 27	0.20	1.07	0.96	0.77	0.54
Uttar Pradesh	8.38	1.26	7.12	6.41	3.83	2.68
Delhi	0 03	0 02	0.01		0.02	0.01

Source: Ministry of Water Resources 1995/96

Use of fertilizers

Table 4.4. The consumption of fertilizers (in million tonnes) in the study area

Year	*Nitrogen*	*Phosphorus*	*Potassium*	*All*
1970/71	0 17	0 03	0.01	0.22
1980/81	0 47	0 10	0.03	0.60
1985/86	0.51	0.10	0.01	0.64
1989/90	0.81	0.25	0.02	1.08
1992/93	0.99	0.26	0.01	1.21

Source: Directorate of Economics and Statistics (Various Issues)

In the study area the use of fertilizers has increased many-folds. The consumption of fertilizers in the study area has increased from 0.22 million tonnes to 1.18 million tonnes during 1970 to 1992 at a compound growth rate of 6 percent per year. The increase is largely brought about by a high growth rate of use of nitrogenous fertilizers (19.47%), which has compensated the negative growth rates of use of phosphatic and potassic fertilizers (-1.05 and -13.17% respectively).

There is a considerable variation in the type of fertilizer material used in different parts of the study area. In the 70s the major nitrogenous fertilizers were Ammonium Sulphate, Urea, Calcium Ammonium Nitrate, but now it is only Urea. Almost 78% of the total fertilizer consumption is nitrogenous fertilizers. The contribution of phosphatic fertilizers to the total amount of fertilizer consumed has increased from 8.5 to 18% and that of potassic fertilizers from 0 01 to 4.5% during the period 1970-92. The major phosphatic fertilizers used in the study area are Diammonium Phosphate and Single Super Phosphate and the major potassic fertilizer used in the region is Muriate of Potash.

The high yielding varieties extract large amounts of nutrients from soil to produce more. The soils of study region are chronically poor in nitrogen (figure 5.1), whereas the status of

phosphorus and potassium in most of the districts is considered to be adequate to support agriculture[3]. The nitrogenous fertilizers are highly subsidized and therefore cheaper than phosphatic or potassic fertilizers. It is argued that this subsidy coupled with expansion of irrigation has been the reason for the use of nitrogenous fertilizers in greater proportions compared to phosphatic or potassic fertilizers. The provision of irrigation has contributed to the increase in fertilizer application as it makes soils capable of holding more amounts of nutrients through improvement in the moisture regime.

Pesticide consumption

Table 4.5. Consumption of pesticides (in tonnes) in the five states coming under the study region

State	1985/86	1986/87	1987/88	1994/95
Haryana	3,608	3,995	3,700	5,250
Himachal Pradesh	690	553	545	290
Delhi	40	46	50	75
Rajasthan	2,444	3,240	2,970	3,900
Uttar Pradesh	6,010	6,550	6,920	11,000

Source: Directorate of Economics and Statistics (Various Issues)

The use of pesticide has become synonymous with modern agriculture. Green revolution was triggered mainly by the introduction of high yielding varieties. These high yielding varieties no doubt produce more but are highly susceptible to pests and diseases. Hence they need greater care and protection. This has led to the increased use of plant protection chemicals in agriculture. The study area is no exception to this, the consumption of pesticides has increased by 160% since 1985 at an annual compound growth rate of 5.4 percent (table 4.5). Bulk of the plant protection chemicals applied are chlorinated hydrocarbon compounds like Dichloro Diphenyl Trichloroethane (DDT) and Benzene Hexa Chloride (BHC), which are banned in most parts of the globe (table 4.6). These pesticides are known to have longer half life periods in soil, and hence persist for a longer time.

[3] Criteria for determining the fertility status of soils(Kg/ha).

Nutrient	Less than adequate	Adequate	More than adequate
Nitrogen	< 280	280 - 560	> 560
Phosphorus	< 22 9	22.9 - 56.33	> 56.33
Potassium	< 141	141 - 336	> 336

Table 4.6. Consumption of pesticides banned or restricted in the developed countries but used in India in 1995 (tonnes)

Pesticide	Use in Agriculture	Use in Public Health
BHC	24000	6305
Carbofuran	280	-
DDT	-	8181.25
2,4, Dichlorphenoxy acetic acid	-	1200
Dichlorvos(DDVP)	1500	
Dimethoate	1900	
Endosulphan	4600	
Lindane	50	
Methyl Parathion	2600	
Monocrotophos	6296	
Mancozeb	4000	
Paraquat	400	
Total	46826	14486

Source CSE 1997

The Cropping Pattern

Table 4.7. The area under major crops grown in the study area (%)

Crops	1970s	1990s
Rice	6	10
Jowar	3	3
Maize	7	6
Bajra	16	15
Wheat	25	32
Barley	3	2
Total Cereals	**59**	**61**
Gram	11	4
Pulses	**18**	**5**
Oil Seed Crops	3	11
Commercial crops	6	16

It is evident from table 4.7 that the area under cereal crops has remained almost constant, but the area under commercial crops and oil seed crops has increased. Most of this increase in area under commercial and oil seed crops has come by diverting land under pulse crops. As a result the total area under pulses has come down considerably.

Of the total area under cereals almost 70 percent is occupied by just two Crops, Rice and Wheat, which are mostly grown under irrigated conditions. The remaining area is occupied by crops like Maize, Jowar, Bajra and Barley, which are basically cultivated under rainfed conditions. Gram is the major pulse crop grown in the study area It forms as high as 80% of the total area under pulses. Among the oil seed crops mustard is the significant one. Commercial crops mainly consists of Sugarcane, Cotton and Potatoes. The changes in the area under major

crops at the district level is given in table 4.9. A summarized version of the table 4.9 is given below (table 4.8).

Table 4.8. Summary of changes in area under major crops of the study area

Crop	*Number of districts showing a decline in the area*	*Number of districts showing an increase in the area*	*Average growth rate (%)*
Rice	9	22	0 42
Wheat	6	25	2 29
Maize	22	9	-3 38
Bajra	21	10	-2 66
Jowar	20	11	-4 22
Barley	21	10	-1 27
Gram	28	3	-6 63
Oil seeds	5	26	5 25
Sugarcane	19	12	-2 39
Potato	0	31	3 85
Cotton	2	29	2 02

Table 4.9 shows that, the area under cereals (except Rice and Wheat). and pulses has been reallocated to oilseed crops and other commercial crops. But the area under sugarcane has decreased in the last 22 years probably due to water shortage arising out of over exploitation of groundwater resources and declining water tables. The shortage of water has affected the crops like rice and wheat in the districts of Agra, Saharanpur, Mainpuri and Muzzafarnagar, where the area under these crops has decreased. Delhi has registered negative growth rates for area under all the major crops because of diversion of agricultural land for non-agricultural purposes.

Table 4.9. Changes in the area under major crops in the districts of Yamuna river sub-basin during the period 1970-92 (%)

District	Rice	Jowar	Maize	Bajra	Wheat	Barley	Cereals	Gram	Oilseeds	S Cane	Potato	Cotton
Ambala	6.4	5.6	-3.5	2.0	4.0	-1.6	3.6	-10.6	-1.2	-2.3	6.9	6.5
Karnal	3.3	-12.1	-7.3	-9.0	0.8	0.0	0.5	-15.6	-6.7	2.6	3.7	-10.7
Jind	7.7	8.4	0.0	2.5	3.7	-3.4	1.0	-8.2	4.8	-2.2	7.6	6.1
Rohtak	4.8	1.0	-8.1	-3.4	1.5	-3.7	-0.4	-10.2	10.4	-1.9	0.7	0.2
Gurgaon	7.9	0.3	-6.3	-0.2	2.2	-4.5	0.0	-7.7	7.0	-1.4	4.5	0.0
Mahendragarh	0.0	0.0	0.0	-2.8	2.3	-7.0	-2.7	-8.4	10.1	0.0	0.0	0.0
Hissar	5.5	7.8	5.6	-0.5	4.3	3.3	1.1	-1.7	7.3	5.7	4.0	5.2
Shimla	1.6	0.0	1.4	0.0	6.1	9.4	4.7	-21.0	-3.3	0.0	14.4	0.0
Simaur	2.4	0.0	3.8	0.0	3.5	1.8	3.3	-1.4	5.8	0.0	2.7	0.0
Alwar	-6.7	-3.0	0.3	-4.0	3.1	-4.0	-1.2	-3.5	4.4	-9.1	0.0	32.2
Bharatpur	-3.0	2.0	6.1	0.5	0.2	-3.7	-0.5	-4.3	4.6	13.5	0.0	-3.8
Jaipur	5.7	1.8	3.2	0.4	4.7	2.7	0.7	-0.9	6.4	6.0	0.0	2.9
Jhunjhunu	0.0	-16.8	8.3	4.2	13.5	5.5	4.8	3.8	13.3	15.3	0.0	8.8
S Madhopur	-1.9	2.9	-5.8	-0.6	1.0	-6.6	-0.8	-3.3	5.6	-7.9	0.0	0.0
Sikar	0.0	18.0	7.1	0.2	7.7	0.7	0.7	1.4	7.7	1.4	0.0	15.1
Churu	0.0	0.0	0.0	0.2	8.1	3.6	0.3	4.4	4.0	0.0	0.0	6.5
Ganganagar	1.2	-6.7	-9.3	-3.2	3.5	-4.0	1.0	-0.5	8.3	-7.6	0.0	6.9
Agra	-10.1	-8.7	-13.3	-1.6	-1.3	-1.7	-1.6	-8.9	6.4	-8.1	7.8	0.0
Aligarh	-1.3	-11.8	-1.8	-0.3	0.8	0.0	-0.0	-6.1	14.3	-2.0	4.7	0.0
Bulandshahar	0.6	-5.5	0.4	-2.6	0.1	-0.9	-0.1	-6.0	10.6	-0.3	2.7	0.0
Dehradun	1.1	0.0	1.0	0.0	0.8	-2.1	0.4	-9.1	2.0	0.6	4.6	0.0
Etawah	1.4	-1.1	-2.0	-1.1	1.7	-0.1	0.6	-2.0	2.0	-2.4	4.5	0.0
Mathura	3.1	-16.0	-8.3	-1.0	0.9	-2.8	-0.3	-11.2	12.4	-2.3	9.2	0.0
Meerut	-0.1	-2.7	-3.1	-4.2	0.4	8.7	-0.1	-10.5	15.7	4.0	4.0	0.0
Muzaffar Nagar	0.1	-7.4	-8.0	-21.6	-0.3	2.2	-0.8	-12.0	9.7	2.1	5.0	0.0

District	Rice	Jowar	Maize	Bajra	Wheat	Barley	Cereals	Gram	Oilseeds	S Cane	Potato	Cotton
Saharanpur	0 2	8 4	4 1	15 2	0 4	8 1	0 3	14 8	0 2	2 8	5 0	0 0
Uttarkashi	0 2	0 0	-0 2	0 0	-1 0	-6 0	-0 7	-2 8	3 0	0 0	13 1	0 0
Tehrigarwal	-1 9	0 0	-0 2	0 0	-0 6	-1 7	-0 2	-5 3	-1 5	0 0	8 0	0 0
Etah	1 2	-4 0	-0 3	0 9	1 1	1 6	0 3	-2 9	0 7	-0 8	3 2	0 0
Mainpuri	1 1	7 9	1 8	5 6	0 3	2 8	1 1	-6 9	-1 0	-6 4	3 2	0 0
Delhi	-6 0	0 4	-14 6	-8 7	-2 2	-7 1	0 0	-19 5	0 0	-20 1	0 0	-13 0

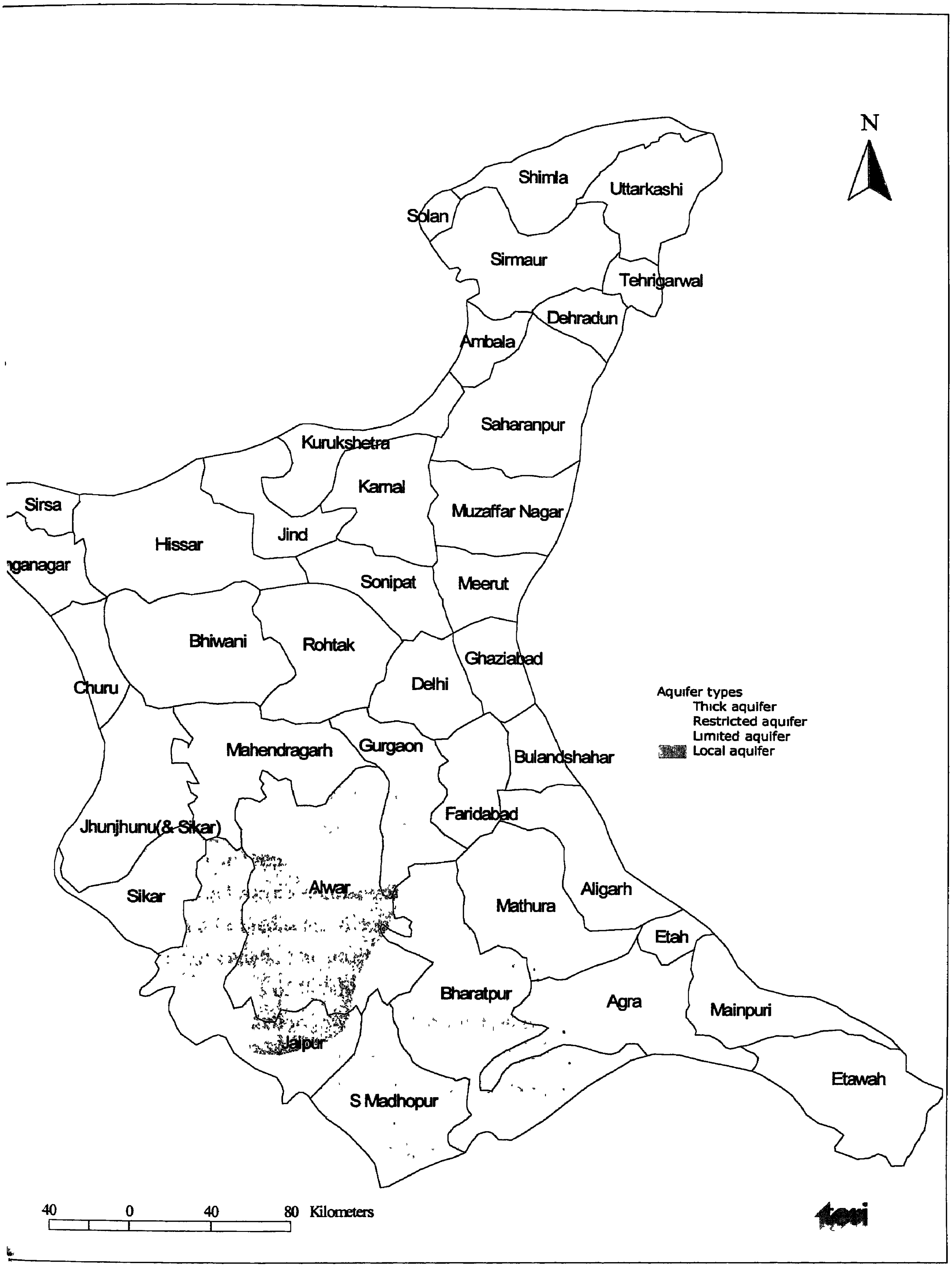

Figure 5.1 Aquifer charecteristics

CHAPTER 5

Impact of agricultural activities on soil resources

Irrigation

Introduction of irrigation in hitherto unirrigated areas causes a chain of agricultural, hydrological and environmental effects. Our inability to foresee the repercussions of the introduction of canal irrigation especially in arid and semi-arid areas, and the lack of adequate measures to combat the changes brought about by irrigation has almost invariably resulted in problems. In the study area land degradation through rising groundwater levels, accumulation of soluble salts in the soil profile[4] ultimately resulting in reduced crop yields or complete abandonment of cultivation have taken place as a result of poor water management practices.

Irrigation induced waterlogging problem: The peripheral parts of the study area are made up of hilly regions of Siwalik range in the north and Aravalli hills in the south. There is a low lying area in the middle portion of the study area. In the northern parts the land surface slopes from the north east to south west, whereas in the south it slopes from the south east to north-west towards the districts of Rohtak-Sirsa axis. This physiographic situation creates a depressional, saucer type zone around this axis forming an internal basin. This internal basin has practically no drainage outlet and the area suffers from lack of surface drainage. The groundwater contours follow more or less a similar pattern as the surface topography. The majority of groundwater flow is directed from north and south parts towards the central inland basin. During the rainy season, when high rainfall occurs in these areas surface water runoff impedes for some weeks and contribute to groundwater rise. The inland drainage basin is almost flat and has no drainage outfall to either Yamuna or Ghaggar river. On some locations, on a limited scale, drains have been excavated and drainage water is lifted by pumps into the canals. The internal basin also has saline groundwater and is the most critical area facing problems of flooding, waterlogging, and rising water-table conditions. The lack of groundwater exploitation (owing to saline nature of groundwater) and addition of water through canal irrigation and floods in the absence of drainage facilities have, therefore, aggravated the problems of water table rise and resulted in waterlogging.

Thus the study area is facing the problem of unchecked rise in the water table. The area affected by this menace lies in the canal irrigated central inland (figure 5.3) drainage basin and Ghaggar drainage basin in the north-western parts underlain by brackish groundwater. The highest average annual rise in water table (figure 4.4) has been observed in

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[4] The vertical cross-section of soil is called as soil profile.

Sirsa (30 cm), followed by Hissar (25 cm) and Bhiwani (23 cm). The average annual increase in the water table in waterlogged districts of study area was found to be around 25 cm.

Another problem of quite opposite nature is experienced in good quality groundwater zones of the study area. In these places over exploitation of groundwater for rice-wheat based crop rotation is taking place. As a result water tables are declining. The highest average annual decline in water table has been in Mahendragarh district (54 cm), followed by Agra (51 cm), Bharatpur and Kuruksheta (48 cm). Nearly seventy percent of the districts (including Delhi) are affected by falling water tables. The remaining thirty percent of the districts are confronted with a rising water table with an average annual increase of 20 cm. It is estimated that the area under the problem of waterlogging, that is water table at a depth of 3 meters or less, in the study area to be 0.7 million hectares (figure 5.3)

Flooding : Higher water tables apart from affecting agricultural crops have many other ill effects on soil. Higher water table reduces the moisture storage capacity of soil. The loss in moisture storage capacity can induce floods even when there is a slight rain. Despite low rainfall, flooding has become a frequent event in the study area, especially in parts of Haryana state. Flash floods of varying magnitude occur in various parts of the study area during monsoon period. The rivers Yamuna, Ghaggar, Sahibi and Markanda cause major floods every year during the months of July to September, due to spilling over the river banks. An alarming situation due to heavy floods was experienced in September 1995 when major parts of Haryana states were flooded (various issues of Times of India, September 1995). Agricultural crops, utility suffered heavy damage when vast areas were flooded due to high rainfall, water spilling over river banks, inadequate drainage systems capacity of Yamuna and Ghaggar basins and upstream breaches of irrigation canals caused by downstream farming communities. Rohtak district was the worst affected with as high as 55% of the total geographical area flooded. Also in other districts such as Bhiwani, Kaithal, Sonepat and Jind more than 20% of the area was flooded.

Soil salinity : In the Yamuna sub-basin, creation of intensive irrigation facilities and inadequate and inefficient water management systems have resulted in the problem of soil salinity. Some of the other factors contributing to the problem include impeded drainage condition, topography, high salt content in the parent material of soil, poor water management

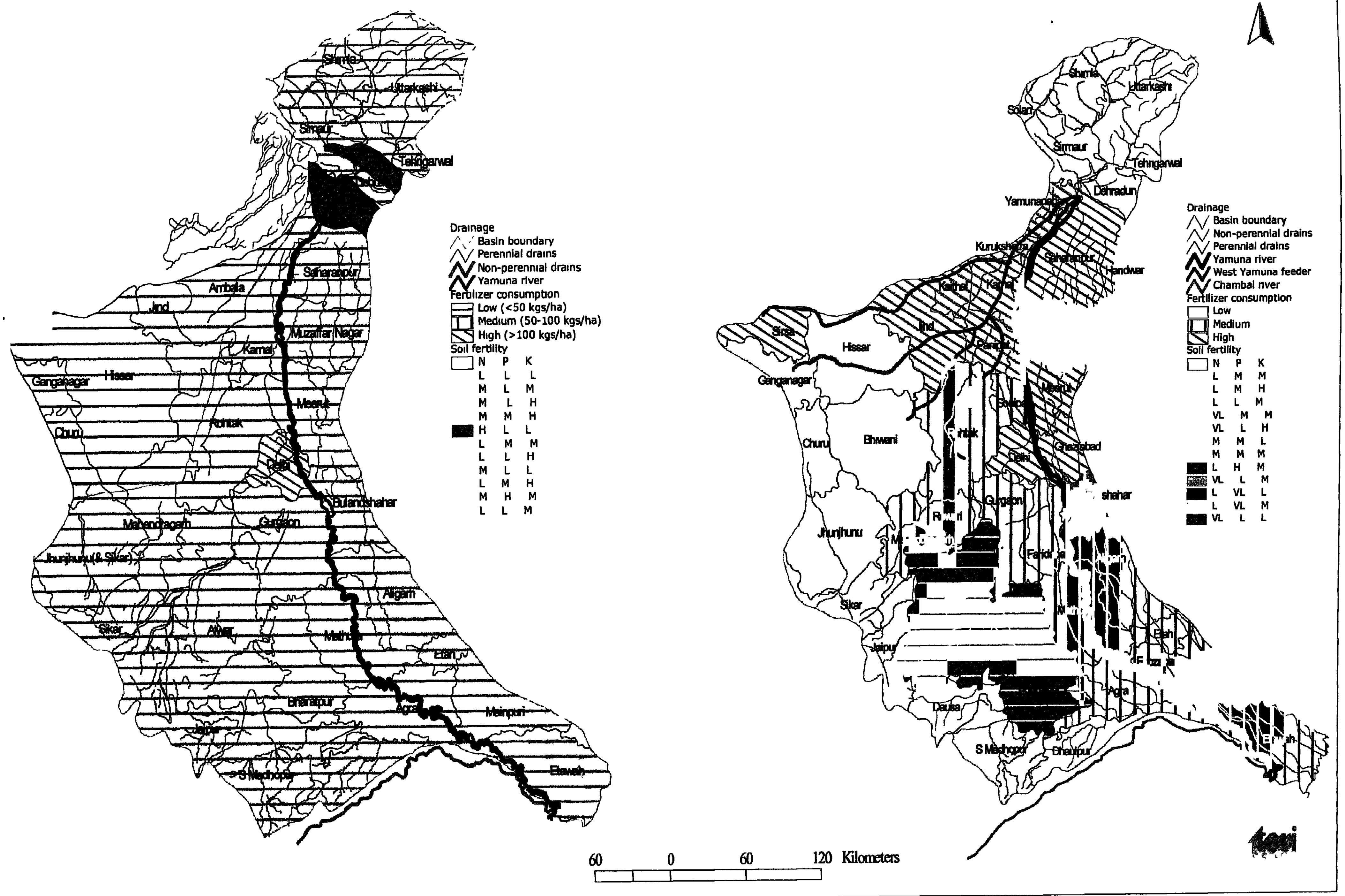

Figure 5.2 Nutrient status of soils and fertilizer consumption

practices, poor quality groundwater and above all arid and semi-arid climatic conditions.

At present in the study area about 1.04 million hectares of land area is affected by the problem of soil salinity (figure 5.3). Approximately 68% of the salt affected area is very severely affected by high salinity rendering agricultural production virtually impossible. In addition to the problem of salinity, some 0.3 million hectares of land in the study area is affected by sodicity. Almost 65% of sodic area is seriously affected. The problem of sodicity is mainly confined to areas with mean annual rainfall varying from 550 to 1000 mm and are found in Karnal, Kurukshetra, Ambala, Gurgaon, Faridabad, Jind and Sonepat districts in Haryana, Aligarh, Etah, Etawah, Mainpuri, Meerut in Uttar Pradesh (see figure 5.3). In some districts both the problems occur in varying degrees. Thus the expansion of irrigation in parts of the study area affected by shallow water tables, poor groundwater quality and soil salinity has threatened the sustainability of agriculture and the economy of the regions.

Sewage water irrigation: The use of sewage water for irrigation is the most prevalent method for the disposal of sewage in study area. The use of sewage adversely affects the health of the agricultural workers employed in the sewage irrigated area. This also affects the health of the population living near the farms or consuming agriculture/horticulture crops grown by using sewage water. Although the epidemiological evidence in India is lacking for establishing the relationship between the population eating sewage grown vegetables or the population living near the farm and the gastrointestinal diseases among them, it has been established by various surveys that sewage farm workers in India, are victims of helminthic infections.

The interaction between soil and waste water can produce beneficial effects on the soil properties with reference to crop production. But long-term use of sewage water can lead to exhaustion of soil system due to accumulation of organic matter and heavy metals. The heavy metal accumulation in soil can lead to biomagnification after entering food chain. Another serious effect of continuous use of sewage water is the pollution of groundwater. Thus it is imperative that sewage must be well treated and converted into well oxidized effluent and stabilized sludge before use in agriculture. The soil, the cropping pattern, the quality characteristics of sewage, its application rates, meteorological conditions and the irrigation schedule are very much interrelated. Therefore a scientific approach is needed in proper design and management of sewage irrigated farms. This equally applies to distillery, tannery and other industrial effluents in agriculture.

Adverse effects of fertilizers use

Nitrate toxicity

The low levels of fertilizer use in 1970s (see figure 5.2) coupled with mounting population pressure on land for food has resulted in increased fertilizer use over time, in the study area (see figure 5.2). A visible and dramatic response by crops to the application of nitrogenous fertilizers has led to farmers using nitrogenous fertilizers in greater proportions compared to phosphatic or potassic fertilizers, most often in an inefficient manner. This excessive use of nitrogenous fertilizers is considered to be responsible for increase in nitrate pollution. Accumulation of nitrates in the soil which are in excess of crop requirements have a number of implications. The first and the most obvious is the leakage of nitrate into the drainage system and hence to the drinking water. The nitrate produced in agricultural soils (non-point sources) is transported to surface water bodies where it contributes to eutrophication effects

There are a few reports of groundwater contamination by nitrates in different parts of the country. Handa *et al.*, in 1982, during their detailed scanning of groundwater samples in Uttar Pradesh have observed nitrate levels of 694, 558, 438, 350, 390 mg/l, respectively in certain pockets of Meerut, Jhansi, Hamirpur, Varanasi, and Unnao. However, in most of the wells the nitrate level is invariably below 30 mg l and in surface water samples below 10 mg/l. The higher levels of nitrate in these stray samples have been attributed to extensive use of farmyard manure. Singh *et al.* (1987), have reported that in extensively irrigated coarse textured highly percolating soils of central Punjab 40-50 % of applied nitrogen is lost due to leaching. The mean concentration of nitrogen in groundwater was 3.88 mg/l during 1982 rainy season, against 1.02 mg/l in 1975. 10 % of the groundwater samples were having nitrate more than 50 mg/lit. Bajwa *et al.* (1992) tested 236 samples of water for nitrate contamination from 21 to 38 meters deep groundwater in different blocks of Punjab. As high as 78% of the samples contained less than 20 mg l NO_3^- and 21.6% showed nitrate levels between 5-10 mg/l. In 367 groundwater samples collected from 9-18 meters deep hand pumps located in village in habitations showed appreciable nitrate concentrations. 64% samples showed nitrates between 5-10 mg/lit and 2% of the samples showed nitrate levels above 10 mg/lit nitrogen. These figures do not indicate any rise in nitrates levels as indicated by Singh *et al.*, (1987).

The water quality assessment carried out by the National Environmental Engineering Research Institute (NEERI), Nagpur, have shown that some of parts of the study area have

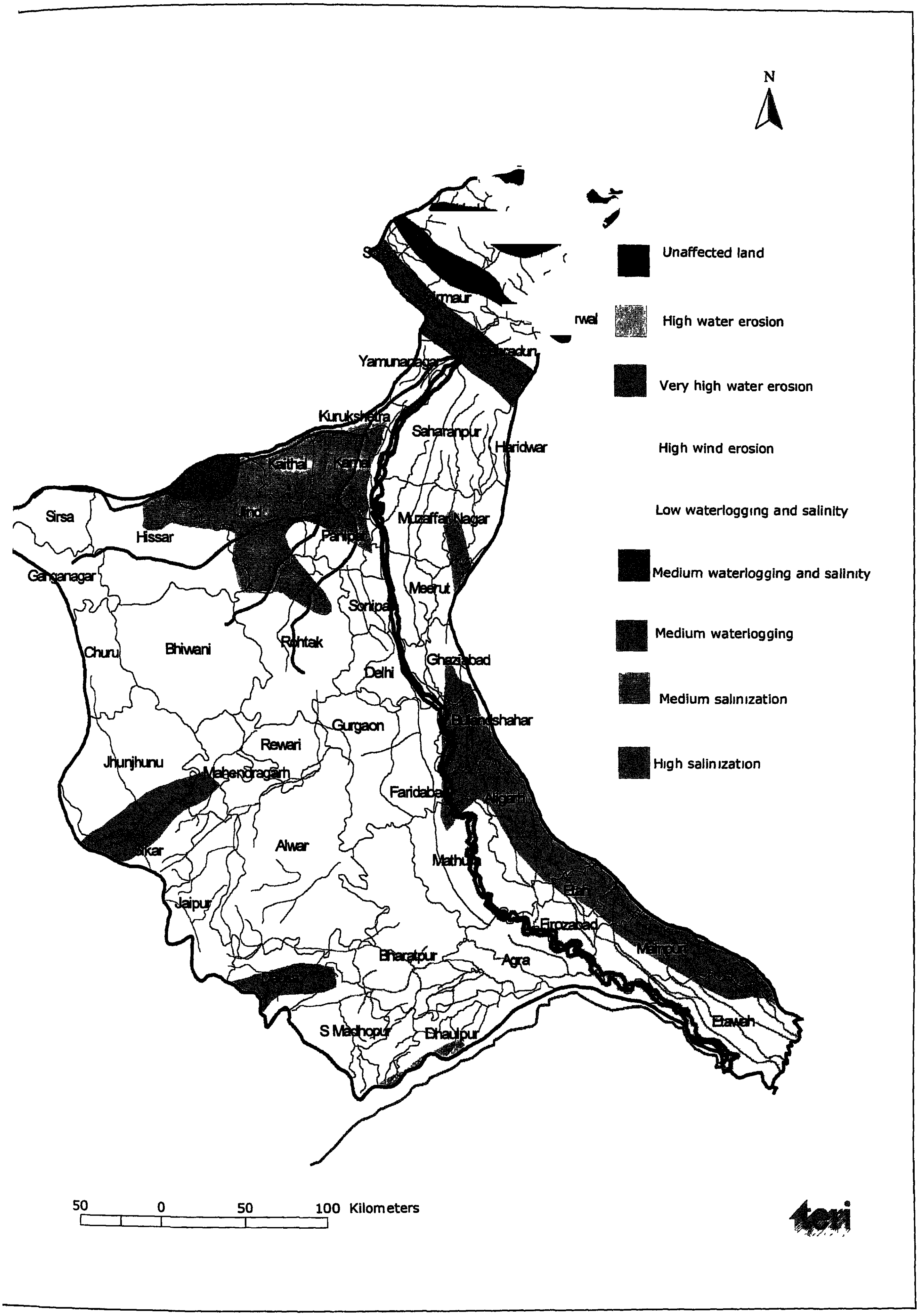

Figure 5.3 Type and extent of soil degradation

nitrate levels higher than the permissible limit[5] in drinking water (table 5.1).

Table 5.1. Nitrate levels in groundwater samples in study area

District	*Total number of samples*	*Number of samples having > 45 mg/lit*
Faridabad	200	45
Gurgaon	415	104
Parts of Rajasthan	351	220

Source Handa 1987

Adverse effects of excess nitrates in soil and water: Higher concentration of nitrates in soil and water has adverse effects on environment and human health (table 5.2). Entry of nitrates into aquatic ecosystems like pond, lake, or river leads to eutrophication effects. Surface water bodies support a wide variety of lower and higher organisms. When nutrient elements (like nitrogen) in the form of nitrates are added to an aquatic ecosystem, algae and other aquatic plants grow faster than the rest of the members. This accelerated growth of algae and other aquatic plants is undesirable for the simple reason that it results in suppression of other organisms supported by these ecosystems. Further this results in depletion of oxygen in water leading to death of fish etc. The enhanced growth of algae imparts offensive taste and odor to water, resulting in the reduced recreational use of these water bodies.

Table 5.2 The adverse effects of nitrates

Environmental disorder	*Impact on human health*
Eutrophication	Methaemoglobinemia
Ecosystem damage	Cancer
Excess plant growth	Respiratory illness
Plant toxicity	

Source Singh and Bhattacharya 1994

Impact on human health

Methaemoglobinemia: Consumption of nitrate rich food, vegetables and water results in health disorders in human beings. Nitrate is considered as toxin in adult bodies and is usually excreted in urine. But any delay in the absorption of nitrates results in conversion of nitrate to nitrite This 'nitrite' is toxic to human body. The nitrite molecule combines with the

[5]A concentration of 45 mg/l is considered to be the maximum permissible limit.

Haemoglobin molecule of blood and prevents it from carrying oxygen This condition is called 'Methaemoglobinemia' (Ishwarappa *et al.* 1994).

Other ill effects: Excess nitrate in drinking water, according to various studies , produces congenital malformations and undrovascular effects Studies conducted on animals have indicated that chronic exposure to high levels of nitrate can make thyroid gland more prone to goitrogens (Addiscott *et al.* 1991).

The problem of Heavy metal pollution

Besides nitrate pollution, a substantial load of heavy metals[6] are added to soil and water through fertilizers and manures. The heavy metals which are considered to be threat to the environment and organisms are Arsenic (As). Cadmium(Cd), Chromium(Cr), Copper (Cu), Mercury (Hg), Nickel (Ni), Molybdenum (Mo), Manganese(Mn). Lead (Pb) and Zinc (Zn). These toxicants can enter the environment from a variety of sources, but the most common sources are sewage sludge and fertilizers. Sewage sludge contains many essential elements(to plants) and is used as a manure in agriculture. However, sewage sludge and chemical fertilizers have appreciable amounts of heavy metals (tables 5.3 and 5.4).

Table 5.3 The average composition of sewage sludge

Heavy metal	Concentration by dry weight in ppm		
	Minimum	Maximum	Median
Zinc	101	27800	1740
Copper	84	10400	850
Nickel	2	3515	82
Chromium	10	99000	890
Cadmium	3	3410	260
Lead	13	19730	500
Mercury	1	10600	5
Arsenic	6	230	10

Source: McLaren and Cameron 1990

[6] The term heavy metal can be used to describe a metal with a density of > 5 g/cm^3

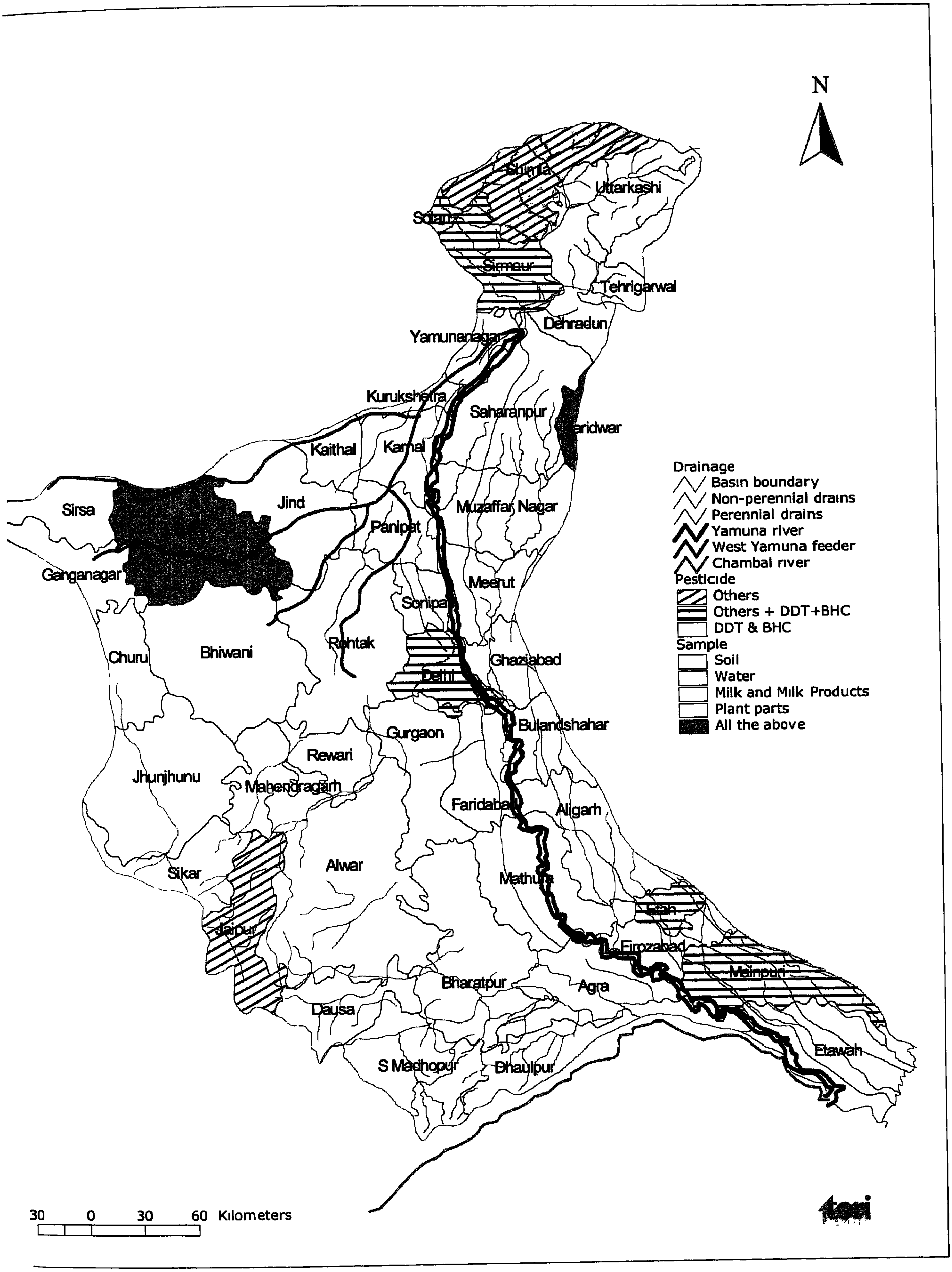

Figure 5.4 Pesticide toxicity reported in1992

Table 5.4. Heavy metals in some to the commonly used fertilizers (ppm)

Fertilizer	*Cu*	*Zn*	*Mn*	*Mo*	*Pb*	*Cd*
Single Super Phosphate	26	59-165	65-270	3.3	609	187
Urea	0.36	0.5	0.5	0 2	4	1
Muriate of Potash	3	3	8	0.2	88	14
Ammonium Sulphate	0.5	0 5	70	0.1	-	-
Calcium Ammonium Nitrate	0.2	6	11	-	200	6
Triple Super Phosphate	2 12	53-100	165-245	0 1	-	-
Ammonium Phosphate	3-4	80	115-200	2	188	0.09

Source Gunnarsson 1983

These heavy metals may accumulate and remain in soil for years following the application Plant's uptake of these heavy metals may result in the entry of these toxic substances into the food chain. Once heavy metals enter the food chain, they tend to accumulate in the body tissues of living organisms, a process called 'bio-magnification', and can reach toxic levels by the time they are transferred to humans. Fish, for example, filter the water it lives in and can therefore accumulate heavy metals in its body tissues. When human beings consume these contaminated fishes they run the risk of contracting health disorders.

Table 5.5 Levels of heavy metals (in ng/lit) in the Yamuna river water near Delhi

Heavy metal	*Concentration in water*	*Indian standards*
Cadmium	0 01	0.01
Chromium	0 01	0 05
Copper	Not detectable	0 05
Iron	8.20	0 30
Nickel	0 03	Not specified
Lead	Not traceable	0 10
Zinc	0 60	5 00

Source · CPCB 1996

In the study area heavy metals have been reported in the waters of Yamuna river (table 5.5). According to Mohapatra *et al.* (1995) leaching of heavy metals from agricultural fields along Yamuna was the most important non-point source of pollution of heavy metals. In districts of Karnal, Panipat and Sonepat a number of industries discharge their effluents rich in heavy metals into the western Yamuna canal. The waste water from these towns is also released into the mainstream. The same water when used for irrigation can result in soil and water pollution leading to entry of these chemicals in to the food chain. The daily average

pollution load which enters Yamuna from these industries is given in table 5.6.

Table 5.6. The daily average pollution load which enter Yamuna (kg day)

Town	Cr	Cu	Fe	Ni	Pb	Zn
Karnal	< 0.04	2.6	180	10	< 0.01	41.3
Panipat	< 0.02	2.7	141	5.2	< 0.02	8.2
Sonepat	11	4.0	168	15	3.3	16
Total	11.06	9.3	489	30.2	3.36	37.2

Source: IWACO 1996

Impact of pesticide use

The use of pesticides in agriculture and public health programmes has contaminated the terrestrial and aquatic food chain. Some chemicals like DDT and BHC have assumed global significance. Although it is possible to check the entry of these chemicals into aquatic environment through industrial and municipal effluents by adopting suitable treatment methods, it is however very difficult to check the entry through agricultural activities and runoff, particularly during the rainy season.

The use of pesticides has a variety of undesirable effects on the environment. These changes include decline in abundance of species and hence the loss of biodiversity, development of resistance to pesticides in target and non-target species, ultimately leading to a reduction in the productive capacity of the ecosystem.

Pesticide residues in soil :Pesticides accumulate in soil and water due to direct application or through indirect means like fallout from pesticide treated crops. Some of these chemicals remain in soil for longer period. Among the pesticides organochlorine insecticides like DDT, Dieldrin persist for longer time in soil, followed by Endrin, Chlordane, Heptachlor, and Aldrin in the decreasing order of persistence. Agnihotri *et al.* (1974), estimated that 97.5% of the soil applied BHC was degraded in six months.

Soils get contaminated with the residues of soil insecticides as well as runoff and rain washing of pesticides from crop canopy. In study area BHC is the most widely used soil insecticide to prevent termite damage to trees and ant problems in nurseries. According to Siddaramappa and Sethunathan (1976), the beta isomer of the BHC is the most toxic of all the isomers of BHC. The half life period of BHC in Indian soils is estimated to around four months (Agnihothri *et al.* 1977).

Pesticide residues in water: Both surface and groundwater bodies receive contaminants through soils. The water samples from Delhi were found to be contaminated with the residues of DDT(Bindra 1973 and Aggarwal 1978). Pillai and Aggarwal (1979) reported that water samples from Yamuna water showed DDT residues ranging from 0.062 to 0.963 parts per billion (ppb). Kalra and Chawla in 1981 detected the residues of HCH (other name for BHC) in water samples from Punjab. The mean concentration was 0.9 ppb against the WHO permissible limit of 1 ppb

Pesticide residues in plant parts. The grape samples from Ludhiana, Punjab, found to contain residues of DDT, Lindane and Malathion (Singh and Chawla 1979). The concentration of pesticide residues in food grains like wheat and rice from different places of India showed the presence of DDT and BHC residues that any other pesticide contamination (Sharma *et al.* 1989. Ahuja and Awasthi 1993). Rice grain samples from Haryana tested positive for HCH (Hexa Chlorane Hexane) contamination in 85% of the samples collected (Balwinder Singh and Dhaliwal 1993).

Pesticide residues in human beings: The residues of pesticides in soil, water and plants can enter human beings upon consumption of food grown on these contaminated soil. or direct consumption of pesticide contaminated water and plants. Inside the human body it gets biomagnified and tend to accumulate in adipose tissue, blood, milk and cerebro-spinal fluid. DDT and BHC residues in human body have been reported from various parts of India. The TERI team has carried out an extensive survey of literature on pesticide toxicity in the study area and a summary of these findings is presented in table 5.7 and figure 5.4 shows the districts having pesticide toxicity problem.

Table 5.7. Pesticide toxicity in and around the Yamuna river sub-basin

District	*Sample*	*Chemical(s)*	*Concentration*	*Remarks*	*Source*
Farrukhabad, UP	Ganga river water Groundwater	Monocrotophos, Quinalphos, Methyl Parathion and ethion Malathion, Monocrotophos		Concentration of organophosphorus are much less than those previously detected	Mohapatra et al. 1994
Farrukhabad, UP	Groundwater	HCH, DDT, Aldrin, Endosulfan and heptachlor	> WHO stds	Polluted ganga water recharging gw, monsoon rains carrying undegraded residues downwards from the soil	Mohapatra et al. 1995
Farrukhabad, UP	Ganga river water	HCH, DDT, Aldrin, Endosulfan, Heptachlor	Isomers of alpha-HCH, p,p\prime\-DDT and alpha-endosulfan >other isomers of HCH, DDT and endosulfan	Beta isomer of HCH accumulated in aquatic environment. Aldrin concn > dieldrin Aldrin residue exceeded WHO guidelines conc of heptachlor occasionally exceeded specific limits	Agnihotri et al. 1994
Shimla, HP	Potato tubers	Monocrotophos, Phosphamidon, Methamidophos, Formothion	Residues of monocrotophos, phosphomidon and formothion were undetectable(< 0 02 ppm) Residues of methamidophos were 0 09 and 0 14 ppm	Cooked potatoes had no residues of methamidophos	Misra et al 1990
Hisar	Soils and Pond water	HCH, DDT	HCH isomers 0 13 ug/g soil DDT were 0 045 ug/g soil HCH residues pond water 2 2ug/g DDT residues 0 1 to 0 2 ug/lit	Contamination of soil and pond water with HCH was greater than with DDT	Kumari et al. 1996

District	Sample	Chemical(s)	Concentration	Remarks	Source
Hisar	Milk samples	DDT, HCH	**Bovine milk samples** DDT 040 ± 0 002 $\mu g/ml$ HCH 0 078 ± 0 042 $\mu g/ml$ **Human milk samples** DDT 0 071 ± 0 032 $\mu g/ml$ HCH 0 157 ± 0 042 $\mu g/ml$ **Baby milk and Butter** DDT 0 744 ± 0 232 $\mu g/ml$ HCH 0 362 ± 0 086 $\mu g/ml$	Of 50 bovine milk samples, 29 were contaminated with DDT and all contained residues of HCH Residues of DDT were above the maximum residue limit (MRL) in 5 samples whereas 15 were contaminated above the MRL for HCH. Eight out of 10 human milk samples were contaminated with DDT whereas all were contaminated with HCH All baby milk and butter samples were highly contaminated with DDT and HCH, and residues of both were above the MRL in 5 and 12 samples, resp Contamination in baby milk was very high	Kathpal et al 1992
Hisar	Soil	α, β, γ, δ isomers of HCH		Degradation of β isomer is the slowest	
Hardwar	Soil, Water and Blood	HCH and DDT	HCH soil 61 12 ug/kg; blood 24 3 ug/lit, water 0 18 DDT soil 270 51, blood 38.31, water 0.07	Conc soil > conc blood	Dua et al. 1996
Narora, Kachala, Fatehgarh and Kannauj, UP	Sediments of river Ganga	Organochlorine and Polycyclic aromatic hydrocarbon	Fatehgarh total organochlorine 0.038 to 0 129 ug/g at Kachala	γ BHC, aldrin, dieldrin, heptachlor,heptachlor epoxide, Phenanthrene were detected in 56,56,40 43, 53, 56% of samples Since the consumption of pesticides is low source is municipal/sewage waste water from the residential areas	Ahmad et al 1996

District	Sample	Chemical(s)	Concentration	Remarks	Source
Jaipur, Rajasthan	Soil	Carbaryl	Persistence of carbaryl Black soil > sandy soil	The ½ life period varied from 10 to 10.81 in sandy soils to 14 to 15.75 days in Black soil	Ali et al. 1995
Udaipur	Soil	Heptachlor and Heptachlor epoxide		The pesticide was degraded by the end of crop period and it was not detectable in second crop	Shivankar and Kavadia 1992
New Delhi	Soil	Temephos		Persisted beyond 84 days	Prasad and Jain 1990
New Delhi	Soil	Carbofuran	0.08 ppm	Undetectable after 28 days	Dhuri et al. 1988
Solan	Apple Tomato Capsicum	Ethylene bis-dithiocarbamate	0.024-6 724 ppm Apple 37 0 028 - 7 89 ppm Tomato 44 1.671 - 12 812 ppm capsicum 6 0 024-0 159 ppm Methyl parathion	9 apple > MRL (3 ppm Carbon di-sulphide) 8 tomato >MRL 4 Capsicum >MRL A total of 7 were contaminated with methyl parathion	Dubey and Nath 1995
Different agroclimatic zones, H P	Bovine milk samples	DDT, HCH	0 01 ug/ml γ HCH	10 % of samples > MRL DDT 26 % of samples > MRL HCH	Kumar et al. 1996
Delhi	Soil, Earthworms, Water(River Jamuna), fish and clams from different sites in Delhi	Aldrin and Dieldrin	Conc of both were more in earthworms than sandy loam soil Dieldrin were higher in fish than ambient water	Aldrin level was same for fish and clams	Nair et al. 191
Palampur, H P	Cauliflower	Endosulfan, Fenitrothion Malathion Phosalone Quinalphos	Endosulfan and phosalone were relatively more persistent	Phosalone remained active for 4 wks, where as remaining were effective for 1-3 wks	Dubra and Hameed 1990

District	*Sample*	*Chemical(s)*	*Concentration*	*Remarks*	*Source*
Shimla, HP	Potatoes	Phorate and Disulfoton	>0 5 ppm(tolerance limit) for 118 days after planting	Residues of both were within tolerance limit in cooked potatoes	Misra and Agarwal 1992

Pesticide residues have been detected in the waters of Yamuna in various studies under taken by CPCB. Table 5.8 presents the concentration of these toxicants in different segments of Yamuna river in the study area.

Table 5.8 Pesticide residues in different segments of Yamuna river (ng/l) during Feb 1995.

Location	BHC residues	DDT residues
Hathnikud	313 25	Not Traceable
Kalanaur	348 22	Not Traceable
Sonepat	304.52	Not Traceable
Palla	229 76	Not Traceable
Mid-stream Nizamuddin	211.00	12
Quarter stream Nizamuddin	220 00	11
Agra canal midstream	375.71	12
Agra canal quarter stream	294.23	Not Traceable
Mazawli	58 89	Not Traceable
Mathura upstream	236.74	Not Traceable
Mathura downstream	232.74	Not Traceable
Agra upstream	376.56	Not Traceable
Agra upstream (midstream)	104 90	Not Traceable
Agra down stream (quarter stream)	160 00	Not Traceable
Bateshwar	351 08	Not Traceable
Etawah	77.87	Not Traceable

Source: CPCB 1996

Impact of agronomic practices and crop management in the study area on soil resources

The crop management and agronomic practices have a significant influence on the soil. In the Yamuna sub-basin, the area under forests is very less (around 2 %), therefore vegetation cover to soil, which acts as a protection against the impact of rainfall, mainly depends on the agricultural cropping practices. The various components of crop management are choice of crop, crop canopy, root factor and that of agronomic practices are land preparation, time of planting, direction of planting etc.

The study area has almost 60% of the cultivated area under cereal crops. These crops make soil highly susceptible to erosive actions of water and wind as they require clean cultivation and frequent intercultural operations. Therefore these crops are called as 'soil robbers'. Legume crops (pulses) on the other hand, are called as 'soil conserving' plants. These crops make soil resistant to erosive actions of water and wind. This is because legumes provide better canopy cover which is one of the factors that alter soil loss dramatically. The amount of soil splash depends on the area of land exposed to the direct impact of rain. Legumes reduce the amount of soil splash as they expose less land area to rain. The roots of the plants are the best binding forces of soil particles. Binding of soil particles makes them resistant to erosion. It has been observed in various studies that grass roots are the excellent soil binders, followed by legumes. The roots of legumes are effective in preventing soil erosion, probably, because of the fact that the amount of root mass produced per unit area is

higher than that of cereals. Table 5.9 gives the amount of soil lost under different crop canopies.

Table 5.9 Soil loss under different crops

Crop	*Loss of water (mm)*	*Soil loss(tonnes/ha)*
Sunhemp(legume)	31.7	286
Fodder Jowar	49.3	371
Maize (Cereal)	76.1	538
Cultivated	291	2167

Source: Bhatt *et al.* 1971

The agronomic practices like land preparation also play a major role in controlling the soil erosion. The cultivation of most of the minor millets and cereals needs preparation of fine seed beds. Fine seed beds make soil highly susceptible to erosive action of water and wind. On the contrary most of the legume crops need coarse seed beds. Presence of big clods facilitate easy infiltration of rain water and reduces the surface run off. Another important agronomic practice is time of sowing. The time of planting plays a major role in deciding the erodability[7] of soil. Time of planting of crops needs to be so adjusted that the maximum canopy synchronizes with high intensity rains to reduce the impact of rainfall on soil. Unfortunately in the Yamuna river sub-basin the area under legumes has declined over time and in its place erosion permitting crops like cereals and widely spaced crops like cotton and potatoes are being cultivated. This has resulted in substantial area under the high and very high classes of soil erosion (figure 5.3). It is estimated that an area of 3.75 million hectares is affected by the problem of soil erosion (table 5.10). In addition to erosion cultivation of these crops has resulted in pollution of soil and water as a large amount of pesticides is applied to enable their cultivation.

Erodability of soil is the susceptibility of soil to erosive forces.

Table 5.10. The area under different types of soil degradation in the study area (Hectares)

District	Water Erosion High	Water Erosion Very High	Wind Erosion High	Salinity Medium	Salinity High	Waterlogging Medium	Waterlogging and Salinity Low	Waterlogging and Salinity Medium	Stable
Kurukshetra	5689	0	0	13563	0	0	5307	0	0
Karnal	0	0	0	77697	0	0	14557	0	0
Jind	11792	0	0	126729	0	0	0	37819	0
Sonipat	47903	0	0	0	0	0	2845	0	0
Panipat	38689	0	0	42272	0	0	9873	0	0
Rohtak	219513	0	0	33240	0	0	0	0	0
Faridabad	84452	0	0	0	9668	0	12984	0	0
Gurgaon	144406	0	0	0	0	0	0	0	0
Mahendragarh	64276	12189	0	0	0	0	0	0	0
Bhiwani	119406	0	148384	0	0	0	0	0	0
Hissar	96351	0	103328	37743	0	0	0	3730	0
Sirsa	0	0	92851	0	0	0	0	0	0
Rewari	74342	0	0	0	0	0	0	0	0
Kaithal	0	0	0	53247	0	0	0	0	0
Yamunanagar	33675	3611	0	0	0	0	8788	0	0
Shimla	69928	0	0	0	0	0	0	0	92148
Simaur	42079	50283	0	0	0	0	0	0	23972
Solan	5504	7655	0	0	0	0	0	0	0
Alwar	426311	0	0	0	0	0	0	0	0
Bharatpur	180145	0	0	72233	0	0	0	0	0
Jaipur	129634	2	0	0	0	0	0	0	0
Jhunjhunu	201704	44121	12450	0	0	0	0	0	0
S Madhopur	141736	5090	0	16543	0	0	0	0	0
Sikar	65286	34552	0	0	0	0	0	0	0
Dhaulpur	80468	0	0	9843	0	3614	0	0	0
Dausa	54904	40273	0	0	0	8206	0	0	0

District	Water Erosion High	Water Erosion Very High	Wind Erosion High	Salinity Medium	Salinity High	Waterlogging Medium	Waterlogging and Salinity Low	Waterlogging and Salinity Medium	Stable
Churu	10680	0	75617	0	0	0	0	0	0
Ganganagar	0	0	87360	0	0	0	0	0	0
Agra	44187	0	0	0	0	131434	0	0	0
Aligarh	0	0	0	0	117239	27751	0	0	0
Bulandarshahar	4920	0	0	0	63582	0	4446	0	0
Dehradun	65384	22555	0	0	0	0	0	0	25560
Etawah	0	0	0	0	19351	159649	0	0	0
Ghaziabad	20293	0	0	0	12775	0	32445	0	0
Mathura	98209	0	0	0	9833	80294	442	0	0
Meerut	25105	0	0	0	8264	0	60633	0	0
MuzaffarNagar	94481	0	0	0	15823	0	50000	0	0
Saharanpur	145296	26594	0	0	0	0	48629	0	0
Uttarkashi	28078	0	0	0	0	0	0	0	132586
Haridwar	20910	1090	0	0	0	0	0	0	0
Firozabad	1941	0	0	0	21641	47833	0	0	0
Tehrigarwal	4740	0	0	0	0	0	0	0	27516
Etah	0	0	0	0	31367	6356	0	0	0
Mainpuri	0	0	0	0	95316	52524	0	0	0
Delhi	77719	0	0	0	0	4997	0	0	0
Total	2980134	248015	519991	483108	404860	522658	250948	41549	301783

Source : Based on analysis of spatial information carried out by TERI team by using the Geographic Information System

CHAPTER 6

Developing physical accounts for soil degradation

Loss in agricultural production: The degradation of soil has a number of implications. The most significant of these impacts is a reduction in the productivity of soils. This results in reduced production of food grains. An attempt to estimate the loss of food grains due to soil degradation has been done by following the methodology described in chapter 2 of this paper. The yield reduction values for seventy classes of different types of soil degradation as indicated by the national bureau of soil survey and land use planning were used in this study. The existing yield levels of eleven major crops of the study area were used to estimate the production loss (table 6.1). The results show that in the study area, the annual agricultural production loss due to the various problems of soil degradation, is to the tune of 6.0 million tonnes (table 6.2). This accounts to seven percent of the annual production of the region in 1992/93. Two crops, wheat and sugarcane, account for production loss of almost 80%. This may be due to the higher yield level these crops have. The crop-wise reduction in production are given in table 6.2.

Table 6.1.The average yield of major crops grown in the study area(Kg/Ha)

District	*Rice*	*Jowar*	*Maize*	*Bajra*	*Wheat*	*Barley*	*Gram*	*Oilseeds*	*Sugarcane*	*Potato*	*Cotton*
Kurukshetra	3028	606	2000	1143	3791	1143	907	1000	56667	18355	2155
Karnal	2471	606	1500	1000	3759	2073	1000	1000	50000	18355	2155
Jind	2360	500	1608	1463	3632	2500	667	824	44444	18355	2176
Sonipat	2211	375	2000	1500	3589	2000	1000	714	52308	18355	2000
Panipat	2263	500	1608	1000	3759	2073	907	1000	50000	18355	2155
Rohtak	2667	353	1608	1222	3283	1200	615	821	48824	18355	1556
Faridabad	2875	476	1000	1429	3471	2600	1000	1083	37273	18355	2155
Gurgaon	2500	412	1608	1150	2852	2222	545	836	51221	18355	2155
Mahendragarh	2104	606	1608	990	3833	2000	700	988	51221	18355	2155
Bhiwani	2104	500	1608	937	3200	2250	687	941	30000	18355	2269
Hissar	3564	500	2000	1466	4036	2667	628	911	55000	18355	2817
Sirsa	2960	606	1608	1143	4042	2300	719	1043	51221	18355	2727
Rewari	2104	500	1608	1217	3783	3000	625	935	51221	18355	2155
Kaithal	2586	500	2000	1444	4741	2000	1000	833	42500	18355	1375
Yamunanagar	3000	606	1667	1000	3027	2073	1000	1000	38205	18355	2155
Shimla	1232	606	2081	1143	808	1000	536	448	51221	9317	2155
Sirmaur	1635	606	2690	1143	1420	1153	629	471	51221	10862	2155
Solan	1620	606	2142	1143	1333	1002	254	359	51221	16440	2155
Alwar	1236	612	970	614	2604	1810	625	704	46415	18355	2133
Bharatpur	2278	838	1065	1390	2568	1791	1196	916	75800	18355	2115

District	Rice	Jowar	Maize	Bajra	Wheat	Barley	Gram	Oilseeds	Sugarcane	Potato	Cotton
Jaipur	1200	253	1007	918	2291	1560	817	469	34559	18355	2122
Jhunjhunu	2104	571	1053	778	919	934	386	922	46413	18355	2158
S Madhopur	915	713	1058	886	2557	1540	1072	612	70538	18355	2155
Sikar	2104	600	1056	688	2790	1125	522	689	46413	18355	2136
Dhaulpur	1234	532	1111	974	2901	1627	548	756	75802	18355	2155
Dausa	1250	531	1058	927	2118	2053	548	626	46455	18355	2158
Churu	2104	606	1608	641	2287	1541	148	661	51221	18355	2250
Ganganagar	2679	531	1058	1059	2623	1137	383	873	33705	18355	2331
Agra	1904	715	2150	1219	3071	1965	1079	884	53763	21617	2155
Aligarh	1997	714	1912	1146	2732	2555	1325	684	60268	22880	2155
Bulandshahar	1836	707	2084	1184	3586	3436	1367	934	58128	19852	2155
Dehradun	1551	606	1580	1143	1757	1848	1368	596	59755	15490	2155
Etawah	2133	1160	2300	1486	2990	1675	1102	951	39103	11876	2155
Ghaziabad	2191	707	1928	1230	3142	3462	1378	1014	57788	26476	2155
Mathura	2371	715	1071	1055	2984	2566	1291	676	53416	19764	2155
Meerut	2250	709	1903	1344	3203	3441	1379	1013	57788	22786	2155
Muzaffar Nagar	2491	710	1794	1350	2967	3463	1380	1004	63364	22788	2155
Saharanpur	2675	707	1320	1346	2487	3464	1378	871	59376	22788	2155
Uttarkashi	1552	606	1039	1143	1274	1303	889	288	51221	14994	2155
Haridwar	2193	606	1627	1346	2058	3464	1379	673	53972	22788	2155
Firozabad	1800	715	1697	1110	2868	2668	1315	843	55836	27736	2155

District	Rice	Jowar	Maize	Bajra	Wheat	Barley	Gram	Oilseeds	Sugarcane	Potato	Cotton
Tehrigarwal	1413	606	1058	1143	1371	1214	917	566	51221	14994	2155
Etah	1942	715	1967	1349	2401	1890	1165	781	55304	11712	2155
Mainpuri	1898	714	2319	1307	2558	2421	1535	695	32331	13584	2155
Delhi	2104	606	1608	1143	2806	2073	907	793	51221	18355	2155
Average	2104	606	1608	1143	2806	2073	907	793	51221	18355	2155

Source: Directorate of Economics and Statistics Various Issues

Table 6.2 Loss in production of major crops in the study area due to soil degradation (in tonnes)

Crops	*Erosion*	*Salinity*	*Waterlogging*	*Waterlogging and Salinity*	*Total loss*	*Production in 1992/93*	*Loss as % of production*	*Relative share of crops in loss*
Rice	99845	55145	14037	5356	174383	3161543	6	2.9
Jowar	13262	1527	531	73	15392	547219	3	0.3
Maize	69048	37372	6684	769	113873	960941	12	1 9
Bajra	235812	24437	15000	1113	276362	2867889	10	4 6
Wheat	835354	270634	80642	22760	1209391	15221395	8	20.1
Barley	41956	17849	6729	806	67341	820906	8	1.1
Gram	61980	5281	2420	197	69878	812152	9	1 2
Oil seeds	169275	14512	10753	421	194962	1853117	11	3.2
Sugarcane	2741744	631126	33943	220785	3627598	52290991	7	60 2
Potatoes	66231	56238	37066	2575	162110	1934263	8	2.7
Cotton	97945	10670	0	2032	110648	2337832	5	1 8
Total	4432452	1124793	207805	256888	6021937	82808248	7	100.0

Loss of nutrients due to soil erosion: The erosion of soil by water and wind detaches and transports soil particles from agricultural fields. Along with these soil particles it removes an appreciable amount of valuable nutrient elements. This loss of nutrients can be estimated if the concentration of nutrients in soil is known (table 3.1). An attempt has been made to estimate the amount of nutrients lost due to soil erosion (using the information on eroded area given in table 5.8). Table 6.3 presents the results of this exercise.

Table 6.3 Loss of plant nutrients due to soil erosion

Erosion category	Area	soil loss	Total soil loss	Nitrogen	Phosphorus	Potassium	NPK
	Hectares	t/ha	Million tonnes				
High water erosion	2980134	30	89.40	0.05	0 14	3 11	3.30
Very high water erosion	248016	60	14 88	0.01	0.02	0.52	0.55
High wind erosion	519991	30	15.60	0.01	0.02	0 54	0.57
Total	**3748141**	**40**	**119.88**	**0.07**	**0.18**	**4.17**	**4.42**

Removal of nutrients by crops: Information on the amount of nitrogen, phosphorus and potassium removed by different crops is given in table 6.4. The area under major crops (table 6.5) has been utilized to estimate the amount of nutrients lost. It is estimated that every year 4.7 million tonnes of the three major nutrients nitrogen, phosphorus and potassium is removed by growing crops but the corresponding addition through chemical fertilizers falls short of this figure (table 6.6). Various studies conducted on the efficiency of fertilizers in soil found that only 23% of the applied fertilizer is consumed by plants, the remaining 77% is either leached down beyond the root zone or lost by denitrification etc., (Tandon 1992). But in this study to avoid overestimation of losses, a fertilizer use efficiency of 50% was assumed. The results show that out of 4.7 million tonnes removed by plants, only 0.59 million tonnes came from fertilizers. This leaves a balance of 4.1 million tonnes, which obviously came from the soil. If the loss of nutrients due to soil erosion is included, the loss of nutrients from the soils of the study region would amount to 8.52 million tonnes per year.

Table 6.4 Amount of nutrients removed by crops (Kg/ha)

Crops	Nitrogen	Phosphorus	Potassium
Rice	109.80	52.70	246.90
Jowar	52.00	18.00	86.00
Maize	114.00	47.00	105.00
Bajra	30 00	11.00	101 00
Wheat	175 00	95.00	252.50
Barley	54 00	29 00	125 00
Gram	41.00	15.75	30.25
Oilseeds	41.00	15 75	30.25
Sugarcane	132.00	74.70	294.70
Potatoes	85.00	30.00	140.00
Cotton	26.00	20.00	84 00
Total	860.00	409.00	1496.00

Source: Fertilizer statistics 1995/96

Table 6.5 Area under eleven major crops (in hectares) in the study area

Crops	1970/71	1992/93
Rice	664,618	1,091,661
Jowar	465,712	251,091
Maize	706,989	486,966
Bajra	3,288,261	3,059,330
Wheat	3,445,943	5,025,218
Barley	553,354	390,459
Gram	2,506,017	1,452,017
Oilseeds	663,747	2,356,364
Sugarcane	651,596	916,039
Potatoes	38,660	103,520
Cotton	453,703	940,950
Total	13,438,600	16,073,615

Source: Directorate of Economics and Statistics-various issues

Table 6.6 Removal of soil nutrients (in million tonnes) by cultivation of agricultural crops (eleven) in the Yamuna river sub-basin

Nutrient	Removal	Addition	Balance
1970/71			
N	1.14	0.09	-1 05
P	0.60	0 02	-0.55
K	1 89	0 01	-1.87
NPK	3.59	0.11	-3 48
1992/93			
N	1.49	0.49	-1 01
P	0.76	0.13	-0.63
K	2.45	0.01	-2.44
NPK	4 70	0.59	-4 10

CHAPTER 7

Conclusions

In an effort to modify the environment to suit a technology for increasing the agricultural production rather than adopting a technology which is suitable to the region, much of the natural resources of the Yamuna river sub-basin have been degraded. Unsuitable crop management and agronomic practices have contributed to the problem of soil erosion which has resulted in not only in reduced productive capacity of soils but also loss of valuable plant nutrients from the soil. In addition, it has rendered soil unfertile due to heavy withdrawal of plant nutrients without adequate replenishment from external sources.

Inefficient surface irrigation management practices coupled with inadequate drainage has rendered most of the canal irrigated area waterlogged and saline. In as high as seventy percent of the study area water tables are declining and there is a shortage of water. This is basically due to heavy withdrawal of groundwater resources for irrigation in most parts of the Yamuna river sub-basin.

Imbalanced fertilizer application has been the cause of nitrate toxicity. This has contaminated the terrestrial and the aquatic ecosystems with nitrates which are known to have ill effects on the environment and the human beings. In addition to nitrate toxicity these fertilizers are the potential sources of heavy metals which are toxic to living organisms. The incidents of heavy metal toxicity have been reported from many parts of the study area. The Yamuna river, the life line of this region, is known to contain appreciable amounts of heavy metals.

The heavy dependence of modern agriculture on the high yielding varieties has resulted in the increased application of pesticides to protect these plants from pests and diseases. These chemicals have polluted soil, water, plants, animals and human beings. The residues of Organochlorines, which are banned in most of the developed countries, have been detected in the breast milk, the adipose tissues and the blood of humans!, exposing the infants to the potential danger of poisoning.

The degradation of the natural resources, the physical basis of survival for living beings, has increased the cost of survival. Most of the farmers in the study region are poor and not in a position withstand this increase in the cost of cultivation. This triggers several unhealthy reactions. These poor farmers tend to become more dependent on common lands like forests, village common lands for their survival and exploit these resources for fodder, firewood etc. This would lead to further degradation of soils. Therefore unless a the site specific technologies are adopted, the problem of resource degradation will continue to haunt the society.

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SECTION 2

Mineral resource accounts

Lubina Qureshy and Subrata Sinha

Introduction

Conventional macroeconomic estimates, such as GDP, are not the most accurate representation of a country's income. In classical economics, income is regarded as the return on natural resources (land), human resources (labour), and invested capital (capital). However, 'neoclassical economists dropped natural resources from the model and focused on labour and invested capital. In applying the theories to economic development in the developing countries human resources were also dropped as labour was considered "surplus." Thus, development was seen as a problem of savings and investment in physical capital.' (Repetto, Magrath, Wells et al. 1989)

On account of this thinking, there is a difference in the way the value of natural resources is measured. Whereas human-made capital assets are regarded as productive capital and their depreciation is deducted from national income measures, a corresponding deduction is not made for natural capital (such as sub-surface mineral deposits). These are considered abundant, without any marginal value. Thus, no investment costs need to be written off. This approach is, however, deficient in that it overlooks the loss in future revenues because of the omission of the depreciation value of the natural capital, and contradicts the definition of "sustainable" income or the Hicksian concept of income: maximum potential consumption while maintaining capital intact. Natural assets make important contributions to long term economic productivity and, in that sense, they are economic assets. To sum up, therefore, from any income measure it is essential to deduct the depreciation of *all* capital stock—reproducible (plant and equipment) and natural (sub-soil mineral deposits) (Hartwick and Hageman 1993; Born 1992; Repetto, Magrath, Wells et al. 1989).

This chapter deals with the valuation of thirteen minerals found in the Yamuna sub-basin. The study attempts at imputing a value for mineral depletion, though it does not make any deductions from the income measures.

Mineral industry in India

Although India is not a mineral economy[1], the minerals sector makes a significant contribution to the Indian economy. Its share in the GDP is 3% and it provides employment to more than 1.3 million persons (Ghose 1995). The country produces 84 mineral commodities (4 fuel minerals, 11 metallic, 49 non-metallic, and 20 minor minerals) from nearly 3 600 mines. Of these, only 300 are large mines with different levels of mechanization. State mining companies contribute 90% of the total value of minerals, though private sector enterprises dominate in sheer number.

[1] A mineral economy is defined as one where the mineral industry shares more than 10% of the GDP and more than 40% of the aggregate exports, such as Australia or South Africa

Major spurts in the growth of the mineral industry came only after Independence with the adoption of the Industrial Policy Resolution. This intensified the mining of minerals, essential to foster the growth of industries like steel, non-ferrous metals, fertilizers, etc. India is a net importer of minerals and metals, though it has been able to attain self sufficiency in 36 minerals, including abundant minerals like limestone, coal, iron ore, dolomite, baryte, manganese, granite, and bauxite.

With the opening up of the economy in 1991, there has been a shift in the investment climate. The new National Mineral Policy of 1993 and amendments to the Mines and Minerals (Regulation and Development) Act in 1994 have created opportunities for foreign direct investment in the minerals sector.

Accounting practices

In India, the gross value of production of minerals is arrived at using the production approach by calculating the value of output (output times the sale value of the ore at the pit head or the pit mouth value) of each mineral at the state level and deducting the value of corresponding inputs[2]. Subtracting the depreciation of capital from this figure gives the net value added from the mining industry. The depreciation of natural capital (mineral asset base) is not accounted for.

There is much debate on whether depreciation allowance should be subtracted from the Gross Domestic Product (GDP) or the Net Domestic Product (NDP)—whether natural assets should be treated as fixed assets or inventories. If natural resources are regarded as inventories of stocks of goods, i.e., as raw materials, their depletion would be deducted from GDP, as changes in stocks are conventionally subtracted from GDP. It is argued that the concept of depreciation is not applicable to assets that cannot be replaced. Since it is not possible to use receipts from selling minerals to recreate these minerals, GDP should be adjusted. The argument in favour of deducting the depletion allowance from NDP is to regard natural resource stocks as fixed assets as returns from these accrue over long periods of time and they are worn down by use over more than one accounting period (Bartelmus 1996; Vaze 1996).

The need for a more adequate accounting framework is recognized. The United Nations Statistical Office has developed an integrated environmental and economic accounting framework. With respect to the depreciation accounts for natural resources, the United Nations Statistical Office has suggested that countries implement balance sheet

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[2] Details on the values of inputs used in extraction of the ore is presented in the annual return statements submitted by mine owners to the regional offices of the Indian Bureau of Mines (See Annexure I). Annexure I also draws out the methodology used by IBM to calculate the pit mouth value.

accounts for reproducible and non-reproducible tangible assets and link these to conventional accounts through 'satellite accounts'. In other words, depletion accounts should be calculated but kept away from the main tables due to the practical problem that not all national statistical offices are capable of estimating depreciation accounts for natural resource assets. This approach of not integrating these accounts into the main accounts continues to provide a misleading picture of GDP as all countries refer to the unadjusted GDP as the measure of economic performance (Repetto, Magrath, Wells et al. 1989).

Past work

The World Resources Institute prepared physical and monetary accounts for petroleum resources, timber resources, and soil erosion in Indonesia for the period 1970–84 (Repetto, Magrath, Wells et al. 1989). A similar exercise was undertaken by Statistics Canada for preparing the physical and monetary accounts for crude oil and natural gas reserves for the province of Alberta in Canada (Born 1992). The valuation of petroleum reserves in both these studies was carried out using the net price method, explained in a subsequent section. Under a pilot project, the World Bank and the Mexican Instituto Nacional de Estadistica, Geografia e Informatica prepared environmentally adjusted economic aggregates for Mexico. These covered natural resource accounts for the depletion of oil reserves, land use, and deforestation, as well as environmental accounts for the degradation of air, water, and land (Tongeren, Schweinfest, Lutz et al. 1993). The net price method has also been used by Crowards (1996) to incorporate natural resource depletion into the national accounts for Zimbabwe from 1980–89. The accounts have been prepared for woodlands and forests, soils, and minerals.

Mineral resources of the Yamuna sub-basin

Thirteen minerals have been identified for this region on the basis of the time series data available with the Indian Bureau of Mines (IBM). The district-wise occurrence of these minerals is presented in Table 8.1. Most minerals found in the Yamuna sub-basin are mined by the opencast method, with differing degrees of mechanization. The share of total output for all minerals, except copper, and to some extent limestone, is dominated by private sector enterprises (Table 8.2). Table 8.3 shows the industrial use of the minerals found in the region.

Within the region, limestone is the most abundant mineral—reserves were 3.6 billion tonnes in 1990. However, the share of this region in limestone reserves is only 5% of the total for the country. This is on account of the fact that India is generously endowed with limestone Limestone reserves are found in 17 states in the country, of which the principal producers are Madhya Pradesh, Andhra Pradesh, Gujarat, Rajasthan, Tamil Nadu, Maharashtra, Orissa, Karnataka, and Bihar. In relative terms, the Yamuna sub-basin

contributes the maximum towards copper and quartz reserves. Of the total copper reserves of 324 million tonnes, this region contributes 89 million tonnes, or 28% of the total. The share of quartz reserves is 21%. The percentage share of this region in rock phosphate reserves is 16%, closely followed by steatite (or talc), contributing 12%. Table 8.4 presents the mineral-wise share of the Yamuna sub-basin in total Indian reserves.

Table 8.1. Mineral occurrence in the Yamuna sub-basin

State/district	*Minerals*
Delhi	Kaolin, fire clay
Haryana	
Ambala	Limestone
Bhiwani	Limestone, copper, quartz
Faridabad	Kaolin, quartz
Gurgaon	Kaolin, quartz
Mahendargarh	Limestone, copper, quartz, dolomite
Himachal Pradesh	
Simla	Limestone
Sirmaur	Limestone, baryte, gypsum
Rajasthan	
Alwar	Limestone, kaolin, baryte, copper, quartz, calcite, feldspar, fire clay, dolomite
Bharatpur	Baryte, copper, quartz, fire clay
Jaipur	Limestone, kaolin, copper, rock phosphate, iron ore, quartz, calcite, feldspar, dolomite
Jhunjhunu	Limestone, kaolin, copper, iron ore, quartz, calcite, fire clay, dolomite
Sawai Madhopur	Limestone, kaolin, quartz, fire clay
Sikar	Limestone, baryte
Uttar Pradesh	
Dehradun	Limestone, baryte, rock phosphate, gypsum, dolomite

Source: *Indian Minerals Yearbook, 1990, 1993*. Indian Bureau of Mines. Ministry of Steel and Mines Nagpur.

Table 8.2. Method of mining and ownership of minerals found in the Yamuna sub-basin

Minerals	*Method of mining*	*Number of mines (1990)*	*Ownership*
Rock phosphate	Opencast	2	Private
Baryte	Opencast/ Underground	10	Private
Calcite	Opencast	8	Private
Copper	Underground	4	Public
Dolomite	Opencast	6	Private
Feldspar	Opencast	8	Private
Fire clay	Opencast	5	Private
Gypsum	Opencast	1	Private
Iron ore	Opencast	13	Private
Kaolin/ China clay	Opencast	18	Private
Limestone	Opencast	34	Private/ Public
Quartz	Opencast	29	Private
Talc/ Steatite	Opencast	23	Private

Source Director of Mines and Mining Leases, 1992. Indian Bureau of Mines. Ministry of Steel and Mines. Nagpur.

Table 8.3. Industrial use of minerals found in the Yamuna sub-basin

Mineral	*Industry*
Apatite/rock Phosphate	Fertilizer industry, chemical, sugar, glass
Baryte	Abrasive, asbestos product, chemical, glass, oil-well drilling, paint, rubber
Calcite	Ceramic, electrode, glass, paint, rubber, others (abrasive, electrical, pharmaceutical)
Copper	Cable and winding wire, semis and alloys, auto-ancillary, electricals, others (manmade fibre, die-casting)
Dolomite	Alloy steel, cosmetic (soap & detergent), ferro-alloy, fertilizer, foundry, glass, iron and steel, refractory, sponge iron, others (ceramic, chemical, electrode, electrical)
Feldspar	Ceramic, glass, refractory, others (abrasive, electrode)
Fire Clay	Plastic and nonplastic fireclay
Iron ore	Alloy steel, cement, iron and steel, sponge iron, ferro- alloys, others (metallurgy electrode)
Kaolin/china clay	Cement, ceramic, paint, paper, refractory, rubber, others (abrasive, asbestos, chemical, cosmetic, electrical, fertilizer, foundry, glass and textile)
Limestone	Aluminium, alloy steel, cement, chemical, fertilizer, ferro-alloys, foundry, glass, iron and steel, metallurgy, paper, sugar, others (asbestos product, ceramics, cosmetic, electrode, sponge iron, rubber, refractory, textile, oil refinery)
Quartz	Glass industry, foundry industry, iron and steel, cement industry, refractory, ferro-silicon
Talc/Steatite/ Soapstone	Ceramic, cosmetics, fertilizer, paint, paper, rubber, soap and detergent, textile, others (chemical, abrasive, electrode, foundry, refractory, pharmaceutical)

Source *Indian Minerals Yearbook 1993* Indian Bureau of Mines. Ministry of Steel and Mines. Nagpur.

Table 8. 4. Share of recoverable reserves in the study area as a percentage of total Indian reserves for 1990.

Mineral	Reserves in India in million tonnes	Reserves in Yamuna sub-basin million tonnes	Share of Indian reserves in Yamuna sub-basin
Rock Phosphate	115	19	16.17
Baryte	70	1	1.47
Calcite	11	0.13	1.20
Copper	325	90	27 66
Dolomite	4967	54	1 08
Feldspar	16	0.2	0.95
Fireclay	697	2	0.28
Gypsum	239	2	0.95
Iron ore	9602	4	0.04
Kaolin/China clay	986	12	1 22
Limestone	76446	3634	4.75
Quartz	984	208	21.18
Talc/Steatite	84	10	11.85

Source· Growth of Indian mineral industry since Independence (1947–1991) Mineral statistics division. Indian Bureau of Mines Ministry of Mines. Government of India February 1992

Methods

The current study uses the net price method and the user cost approach for calculating the depreciation allowance for all the minerals. The present value method is illustrated for rock phosphate, feldspar, and quartz in Appendix A.

Physical accounts

Resource stocks are recorded in both monetary and physical terms. Monetary valuation of mineral reserves is necessary for calculating wealth measures. But, they are not sufficient for explaining trends in the remaining reserve base from which the income is derived. It is, therefore, essential to supplement monetary accounts with physical accounts, which provide a measure of resource availability in the short or medium term. In other words, the "physical quantities of a resource are at least as useful as monetary values. From the national accounts' perspective, a natural resource is as much an economic as a physical concept" (Born 1996).

The basic accounting identity for the preparation of physical accounts is:

$$\textit{Closing stock} = \textit{Opening stock} + \textit{Reserve accretion} - \textit{Production} \quad (2)$$

where, closing stock is the quantity of remaining recoverable reserves at the end of the year after making deductions for production (depletion)[1] and reserve accretion from the opening stock of recoverable reserves. The remaining recoverable reserves (closing stock) at the end of this accounting period is equal to the opening stock at the beginning of the next year.

The change in stock in a particular year is the sum of depletion and reserve additions/deletions. Since separate data on the latter is absent, and it is assumed that the recoverable reserves figures incorporate these additions, the change in stock in the current study is equivalent to the production (depletion) in that year.

Definition and classification of reserves and resources

In geologic terms, a *mineral* or energy *resource* is a concentration of naturally occurring solid, liquid, or gaseous materials in or on the Earth's crust in such form that economic extraction of a commodity is currently or potentially feasible. Total *resources* are materials that have present or future value and comprise identified or known materials plus those not

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[1] Production is treated equivalent to the depletion of reserves Ideally, a portion of the mining receipts should be treated as value added, as a return for human effort Therefore, in the user cost approach, the net receipts from an asset are broken into two components - user cost and true income

yet identified, but which on the basis of geologic evidence are presumed to exist. Material classified as a *reserve* is that portion of the identified resource from which a usable mineral and energy commodity can be economically (or profitably) and legally extracted at the time of determination. The term *ore* is used for reserves of some minerals. Thus, an ore represents a mineral with a commercial significance, that is, one from which a metal can be extracted.

Of particular interest is the current economic availability of mineral or energy materials, that is, reserves. However, for long term planning, it is essential to know the probability of geologic identification of resources in as yet undiscovered deposits and of technological development of economic extraction processes for presently unworkable deposits. Hence, total resources are reassessed from time to time based on geological, technological, and economic information (United States Department of the Interior 1975).

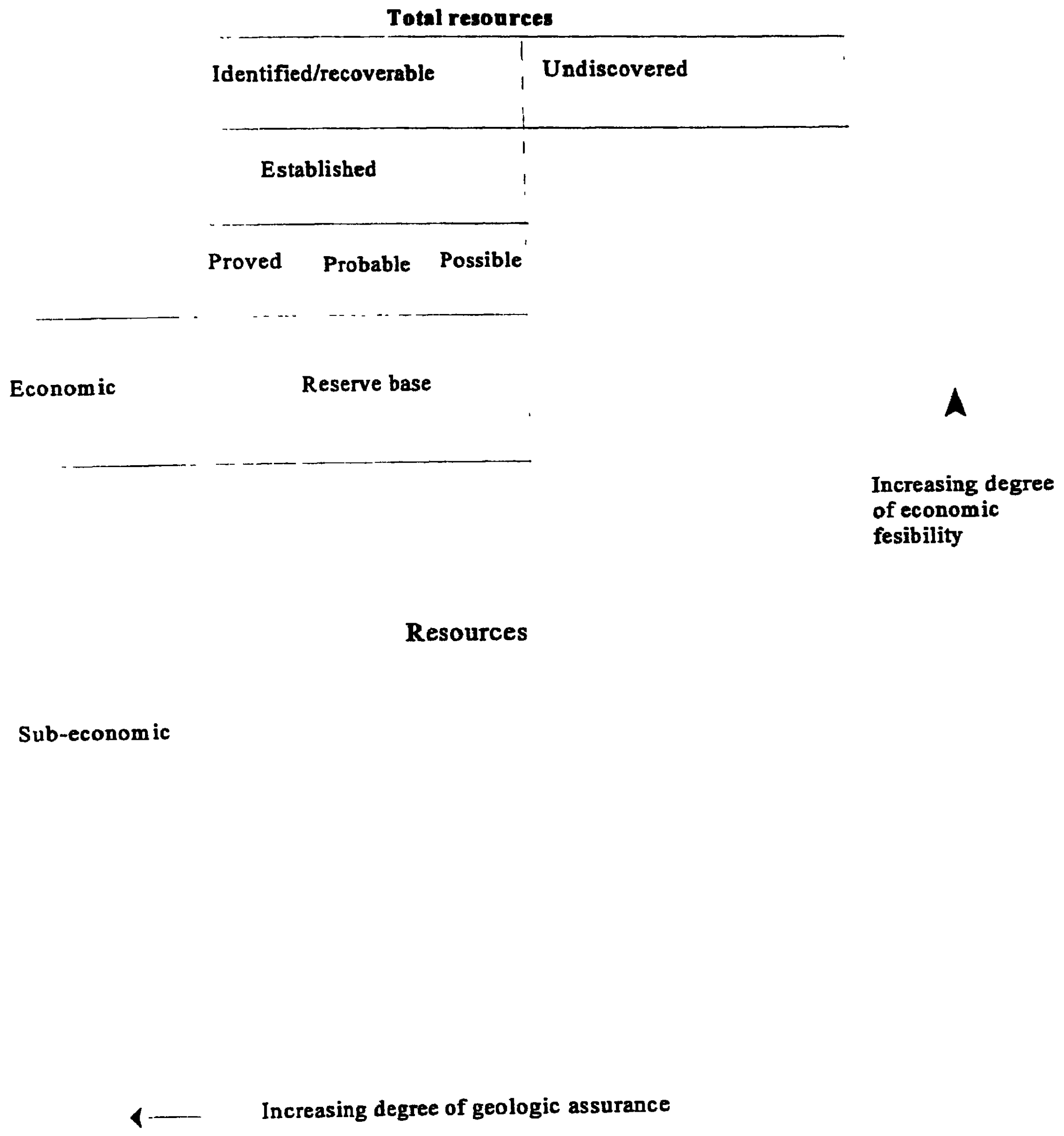
Total resources are classified in terms of economic feasibility and the degree of geologic assurance. In Figure 9.1 the x-axis represents the degree of geologic assurance and the y-axis represents the degree of economic feasibility (McKelvey 1972 cited in Born 1992; United States Department of the Interior 1975).

Identified or *recoverable* resources are defined as specific bodies of mineral-bearing material whose location, quality, and quantity are known from geologic evidence supported by engineering measurements with respect to the demonstrated category. *Undiscovered* resources are unspecified bodies of mineral-bearing material surmised to exist on the basis of broad geologic knowledge and theory. *Identified subeconomic* resources are not reserves, but may become so as a result of changes in economic and legal conditions.

Recoverable reserves are categorized into proved, probable and possible reserves. *Proved* reserves or resources are those for which tonnage is computed from dimensions revealed in outcrops, trenches, workings, and drill holes and for which the grade is computed from the results of detailed sampling. The size, shape, and mineral content are well established. *Probable* reserves or resources are those for which tonnage and grade are computed partly from specific measurements, samples, or production data and partly from projection for a reasonable distance on geologic evidence. Mineral bodies are not outlined completely and the grade is not established throughout. *Possible* reserves or resources are those for which quantitative estimates are based largely on broad knowledge of the geologic character of the deposit and for which there are few, if any, samples or measurements (US Department of the Interior 1975).

According to the United Nations System of National Accounts (SNA), all natural resource stocks are constituted by proved reserves. Proved reserves are those which have a have a significant, but less than 50% chance of being developed (Vaze 1996). Table 9.1 presents different categories of reserves.

Figure 9.1. Classification of reserves (McKelvey box)



Source: McKelvey 1972 in Born 1992, United States Department of the Interior 1975

Table 9.1. Classification of reserves and resources

Category	Definition
Resource	Concentration of naturally occurring solid, liquid, or gaseous materials in or on the Earth's crust in such form that extraction is currently or potentially feasible.
Reserve	Portion of the resource that is geologically identified and can be economically extracted
Ore	Mineral with a commercial significance.
Identified or recoverable resources	Bodies of mineral-bearing material whose location, quality, and quantity are known from geologic evidence supported by engineering measurements, with respect to the demonstrated category
Identified sub-economic resources	Resources that may become reserves when economic and legal conditions change.
Proved reserves	Size, shape, and mineral content well established from detailed sampling. They have a significant but less than 50% chance of being developed.
Probable reserves	Mineral bodies not outlined completely, grade not established throughout, established partly by measurements and partly by projections.
Possible reserves	Least well known; based largely on broad knowledge of the geologic character of the deposit.

Source: Compiled from United States Department of the Interior 197, Vaze 1996.

Monetary accounts

The issue of the appropriate choice of methodology for calculating the depreciation allowance is a crucial one. The theoretically correct basis for asset valuation is the Present Value approach. Two alternatives to this method are user cost and net price method.

The economics of resource extraction

The extraction of non-renewable or exhaustible resources (such as mineral reserves) is fundamentally different from renewable resources, where profit is maximized at that output level where marginal cost is equal to marginal revenue. However, when deciding whether to extract now or in the future, the resource owner has to ensure that current profits are increased as well as that this increase outweighs the reduction in future profits, had the extraction been postponed. This implies two cost components – the marginal extraction cost (from current extraction) and the marginal user cost (from foregone future profits). The revenue from current extraction should be high enough to cover the marginal extraction cost as well as the marginal user cost. According to the *fundamental principle* in the mining, petroleum, and natural gas industries (Gray 1916; Hotelling 1931 cited in Kula 1992) this can be achieved if the market price of a resource net of the extraction cost (or net price) rises at the same rate as the market rate of interest to preclude arbitrage. In case the net price rises at a rate lower than the market rate of interest, ceteris paribus a rational profit maximizer would extract and sell the stock and invest the proceeds elsewhere. In the case where the net price rises at a rate more than the market rate of interest, the owner would not carry out any extraction. Hence, the equilibrium condition is achieved where the rate of increase of the net price is equal to the rate at which the market rate of interest rises.

Concept of economic rent

The concept of economic rent is crucial for monetary valuation. Economic rent is defined as the return to any production input over the minimum amount required to retain it in its present use. It is equivalent to the profit that can be derived from a factor of production. In principle it is calculated as the difference between the international resource commodity price less all factor costs of extraction, including a normal return to capital but excluding taxes, duties, and royalties. The term economic rent is used synonymously with the term net price.

Economic rents from a natural resource primarily consist of Hotelling rents (due to the scarcity or exhaustibility of a resource) and Ricardian rents (due to the differential quality of a resource)[2]. In most models it is assumed that stocks are homogeneous and there are no Ricardian rents. The focus is, therefore, on Hotelling rents arising on account of the scarcity of a non-renewable resource.

Present value method

In this method the future flow of income generated by an asset over its life time is discounted by an appropriate discount rate, usually assumed to be constant over time (Gervais 1990). This approach relies on assumptions about future market conditions – prices, costs, discount rate, production. Further, the choice of the "appropriate" discount rate is difficult in terms of choosing a private or social discount rate. It has to take account of inter-generational equity, social opportunity cost of capital, and social time preference. The choice of the appropriate discount rate has ranged from zero to 22% (Bartelmus 1996; Born 1992). **Appendix** A gives a detailed illustration of the calculation of depreciation values using the present value method for rock phosphate, feldspar, and quartz for the Yamuna sub-basin.

Suggestions towards avoiding speculation on discount rates or other market conditions include the adoption of (1) the *net price method* or (2) the *user cost method.*

Net price method

The net price method is based on the concept of Hotelling rent: under certainty, in the absence of extraction costs and under competitive market equilibrium conditions, the price of a natural resource rises at the market rate of interest to preclude arbitrage (Sundarsen 1984 cited in Born 1992). That is, the net price (average price less the (marginal) costs of extraction, development and exploration, including physical capital costs) of the marginal unit extracted from a resource rises at the same rate as the discount rate or the rate of return on alternative investments. The net price method is a special case of the present value method where, on average, long-run market equilibrium occurs (net price rises at the rate of alternative

[2] Economic rents also consist of locational rents, arising on account of transportation costs, as well as rents due to unexpected price variations.

investments) and the rise of the net price exactly offsets the discount rate (Bartelmus 1996; Born 1992; Gervais 1990)

Most models suggest that the Hotelling or scarcity rent should be used to measure the depletion of a resource. In a competitive economy with homogeneous stocks of a natural resource, Hotelling rents equal the value of economic depreciation or resource depletion. Hotelling rents are defined as output price minus the extraction and discovery costs on the marginal unit times the quantity extracted (Hartwick and Lends 1989 cited in Born 1992).

Calculation of net price

The net price method determines the value of a resource at the beginning of a period (V_t) as the volume of the proven reserve ($Q = \sum Q_t$) multiplied with the difference between the average market value per unit of the resource (P_t) and the per-unit (marginal) cost of extraction, development and exploration (C_t). Thus, we get:

$$V_t = (p_t - C_t)\,Q = N_t \sum_{t=0}^{T} Q_t$$

Given the hotelling rent assumption that net price rises at the market rate of interest the depreciation equation is: $V_t - V_{t-1} = P_t Q_t$[3]

The net price (economic rent: international commodity price less the factor costs of extraction, including a normal return to capital, excluding taxes, royalties, and other costs not a part of the cost of physical extraction) for each mineral was calculated by subtracting the pit mouth value of the mineral from the production cost in each year.

$$\text{Net price} = \text{Pit mouth value} - \text{Production cost} \qquad (3)$$

The monetary value of depletion using the net price method is, then, the product of the net price and the physical depletion (production).

User cost method

This method segregates the net receipts from extraction into capital consumption or user cost and value added or true income. This approach is based on the concept that to convert a finite time bound (constant) stream of receipts from an exhaustible resource into a perpetual income stream (the true income) a part of the receipts (the user cost allowance) should be set aside for investment.' (Bartelmus 1996).

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[3] For further reference consult *Annex. Methods of market valuation of natural resources* in Bartelmus 1996.

The value of depletion (X) under the user cost method is then given by the expression, $R/(1+r)^T$, where R represents the net receipts[4] in the period for which the user cost is being calculated. , r is the (nominal) rate of discount, and T is the remaining life of the reserve. T is calculated as the total recoverable reserves divided by the production in that year. The difference between the net receipts, R and the user cost, X gives the true income or the value added component.

The user cost method is a special case of defining depreciation as the change in (discounted) value of a resource, assuming that the periodic net returns are the same over the remaining life of the resource (T years) (Hartwick and Hageman 1991 cited in Bartelmus 1996).[5]

Critique of the methods

The net price method is widely applied because of its simplicity and because it requires very little information as compared to the present value method or the user cost approach. The present value method, as mentioned earlier, requires information on future net returns, based on estimates of the lifetime of the resource, revenues from anticipated extraction, and future costs of extraction, exploration, and development of the resource. It also requires the determination of an appropriate discount rate. The user cost method, though it simplifies the present value method by assuming a constant income stream, requires the choice of an appropriate discount rate. The net price method only requires information on current prices and costs. However, this method works under very restrictive assumptions of long run competitive equilibrium and homogeneous resource stocks. In reality, market imperfections persist, and resource stocks are not homogeneous. Marginal exploitation costs increase with lower quality of resources extracted, and the rents on the marginal tonnes would increase at a rate lower than the discount rate. Hence, Hotelling rents tend to overstate the depletion value. The estimates of the value of depletion are also higher in case average costs are used instead of marginal costs, and marginal costs are generally higher than average costs (Bartelmus 1996; Born 1992).

The monetary valuation of mineral reserves in this study uses the net price method applied by Repetto, Magrath, Wells et al (1989) to value petroleum stocks in Indonesia. In

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[4] This is equal to the monetary value of depletion using the net price method.

[5] The user cost allowance or depreciation ($\Delta V = PV_0 - PV_1$) at the discount rate, r and the lifetime of the resource T years is given by:
$\Delta V = R\ (1+r)^T$. R is the product of the net price and the depletion (the depletion value in the net price method) in the year under consideration. T is calculated as the total recoverable reserves in a particular year divided by the production in that year. r is the nominal rate of discount assumed equal to 12%. Substituting these values in the above equation gives the user cost, presented in the accounts below.

this method, the change in stock of the resource is multiplied by the current unit net price to arrive at a monetary value of the depletion of the resources. The unit net price is equal to the market price less the cost of discovery, extraction and marketing. The value of mineral depletion equals the net price multiplied by the amount of depletion.

Data

Table 9.2 below presents the data collected for the preparation of the physical and monetary accounts for each mineral in the study region.

Table 9.2. Data used for the study[a]

Data Type	*Time period*	*Level*
Recoverable reserves[b]	1980, 1985, 1990	District
Production	1980–1990	District
Production cost[c]	1980–1990	District
Pit mouth value[d]	1980–1990	Regional
Number of mines	1980–1990	District

[a] Data compiled from 13 volumes (1980–1993) of *Indian Minerals* Yearbook Nagpur: Indian Bureau of Mines. Ministry of Steel and Mines.

[b] See Appendix B for a break-up of recoverable reserves into proved, probable, and possible reserves categories; production per year; and the production cost for baryte

[c] Appendix C shows the components of production cost for a phosphate mine in Dehradun.

[d] The pit mouth value of an ore represents the sale value of the ore at the pit-head. In case of captive mines, the cost of production may be considered to represent the pit mouth value

Recoverable reserves, production, and production cost

The district wise data for recoverable reserves, production, and production cost for each mineral was aggregated to get regional estimates. Production cost for each year was calculated as the average of the aggregate production cost for the region. The aggregate production cost is the total of the production costs for each district. The break up of the production cost is presented in the annual return statements submitted by individual mine owners to the district offices of the Indian Bureau of Mines (Appendix C).

The data on recoverable reserves is available on five yearly intervals (1980, 1985, 1990). For the intervening years, recoverable reserves were calculated using the data on production values for each year. Therefore, the recoverable reserves, for example, for 1981 were calculated using the identity:

$$\text{Recoverable reserves (1981)} = \text{Recoverable reserves (1980)} - \text{Production (1980)} \quad (1)$$

It is assumed that recoverable reserves incorporate additions due to new discoveries as the IBM revises this data on the basis of any information on new discoveries provided by the Geological Survey of India (GSI).

Pit mouth value

Data on pit mouth value was available for each mineral across different states in the Yamuna sub-basin. This was averaged to get a representative figure.

The pit mouth value represents the sale value of the mineral at the pit head. In case of sales effected on Free on Railway, Free on Board, or any other such basis, the pit head sale value should be arrived at after deducting all expenses incurred from the mine to the railway station or port or other point of sale as the case may be. These expenses include transportation, loading and unloading charges, railway freight, sampling and analysis, port handling, export duty, cess, etc.

The costs incurred in the physical extraction include costs of physical capital (fixed assets), cost of material consumed, labour employed and wages paid, and the total salaries (Appendix C). These constitute the cost of production. Other costs, not directly incurred in physical extraction include taxes, royalties, and interest and rent. The pit mouth value constitutes all these costs plus a normal return on capital.

APPENDIX A

Present value method

An illustration of the present value method to calculate depreciation values is presented in this section for the minerals rock phosphate, quartz, and feldspar. The total Indian recoverable reserves for quartz were reported at 984 million tonnes in 1990, for rock phosphate at 115 million tonnes, and for feldspar the figure was 16 million tonnes. The Yamuna sub-basin contributes 22% (ranking second after copper which contributes 28%)[1] to total quartz reserves, followed by rock phosphate, contributing 16%. This region, however, contributes a minuscule share of 1% towards total Indian feldspar reserves. The share in production is 4% for feldspar, 6% for quartz, and 20% for rock phosphate. Whereas the share of the Yamuna sub-basin is small in feldspar reserves, the total Indian feldspar reserves are not large, as compared to either quartz or rock phosphate. Even though the contribution of the region to quartz reserves is relatively high, the contribution to production is just 2% less than that of feldspar. On the other hand, the Yamuna sub-basin contributes a large share of both rock phosphate reserves and production.

The present value (PV) of a natural resource at the end of the accounting period 0 (1990) is the sum of the expected net revenue flows $R_t = N_t Q_t$, discounted at a rate of interest, r, assumed constant over the lifetime, T, of the resource. Thus, PVo is given by Equation (1), where, N_t is the economic rent or net price of the resource in period t and Q_t is the quantity exploited over the period t.

Depreciation

The change in value, or the depreciation of the resource during an accounting period t, is the difference between PV_t and PV_{t-1}. Thus, first year depreciation in our example is given by: $PV_0 - PV_1$, where PV_1 is given by Equation (2).

Assumptions

The unknowns in Equation (1) and (2) are T: the lifetime of the resource; r: the real rate of discount; N_t: the net price of the resource in period t; Q_t: the quantity of the resource produced in period t. Thus, the following assumptions have been used to calculate the present value of the assets.

[1] There is an inconsistency in the data on copper prices, hence the depreciation values have not been worked out

(1) $\sum_{t=0}^{T} Nt\ Qt / (1+r)^t = R_0 + R1/1+r + R2/(1+r)^2 + \cdots + RT/(1+r)^T$

(2) $\sum_{t=0}^{T} Nt\ Qt / (1+r)^t = R_1 + R2/(1+r)^1 + R3/(1+r)^2 + \cdots + RT\ (1+r)^{T-1}$

(3) $Qt = Q_0\ (1+rp)^t$

(4) $RT\ I0 - \sum_{t=0}^{T} Qt$

(5) $I0 = \sum_{t=0}^{T} Qt$

(6) $I0 = Q0\ Q0\ (1+rp)^1 + Q0\ (1+rp)^2 + \cdots + QT\ (1+rp)^T$

Taking the sum of the gemetric series on the right

(7) $I0 = Q0\ (1-(1+rp)^{T+1} / 1-(1+rp)$

or

(8) $I0\ (1-r-rp) / Q0 = 1-(1+rp)^{T+1}$

or

(9) $1 - I0\ (1-r-rp) / Q0 = (1+rp)^{T+1}$

Taking log *on both sides*

(10) $\ln\ (1 - I0\ (1-r-rp) / Q0) = \ln\ (1+rp)^{T+1}$

or

(11) $(T+1) \ln\ (1+rp) \quad = \ln\ (1 - I0\ (1-r-rp) / Q0)$

or

(12) $T+1 = \dfrac{\ln\ (1 - \frac{I0\ (1-r-rp)}{Q0})}{\ln(1+rp)}$

or

(13) $T = \dfrac{\ln\ (1 - \frac{I0\ (1-r-rp)}{Q0})}{\ln\ (1+rp)} - 1$

Real rate of discount: r

r is assumed to be 6 % over the entire period.

Net price: N_t

The net price over the lifetime of the resource is assumed equal to the average of the net price over the last 5 years (1986-1990). Thus, there is an underlying assumption that the real prices remain constant at this average level over the lifetime of the resource.

Quantity of the resource: Q_t

The quantity of the resource is expected to grow at a rate r_p Thus, in any period t, the quantity of the resource is given by Equation (3), where Q_0 is worked out as the quantity of the resource produced in 1990, using the regression equation obtained below.

Rate of growth of production: r_p

The rate of growth of production is calculated after running a regression of production on the period 1980-90 for the three minerals and fitting a linear trend. This is presented in Figures A.1-A.3 (where the y-axis represents production and the x-axis the period 1980-90). The equations of the regression lines for feldspar, quartz and rock phosphate are:

Feldspar	$y = 3.8727 + 0.0364x$
Quartz	$y = 3.1636 + 0.7455x$
Rock phosphate	$y = 40.6 + 9.8091x$

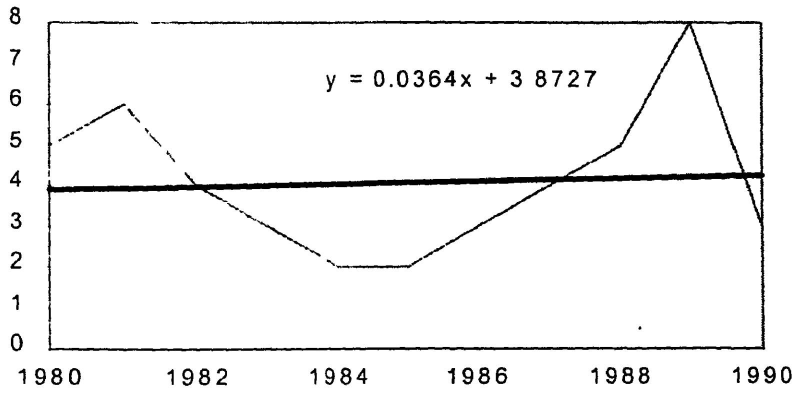

Figure A.1. Regression of feldspar production on the period 1980-90

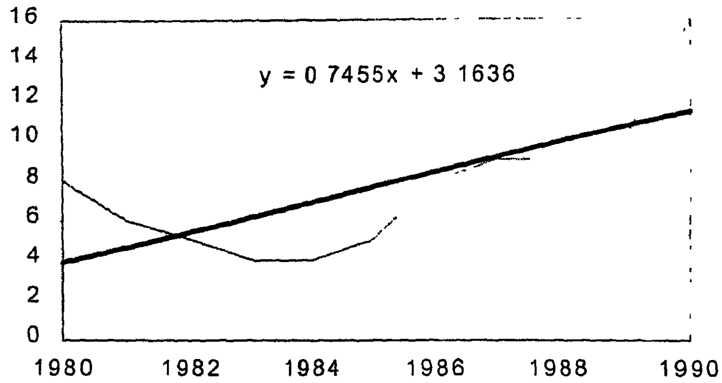

Figure A.2. Regression of quartz production on the period 1980-90

Using the above regression equations, the compound annual growth rate of production can be worked out over the period 1980-90 for each of the three minerals[2] (Table A.1).

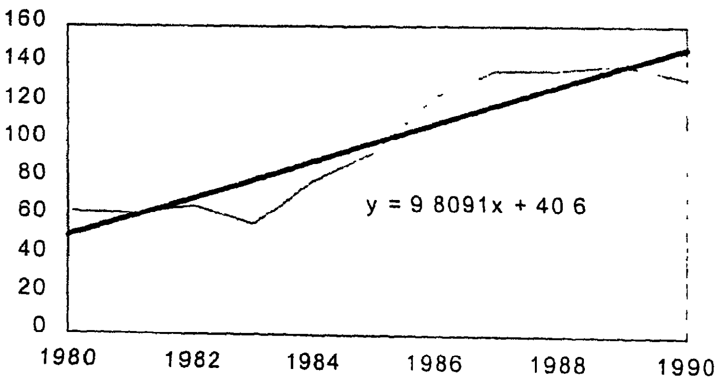

Figure A.3. Regression of rock phosphate production on the period 1980-90

Lifetime of the resource: T

The stock of reserves remaining at the end of the lifetime of a resource (T years) equals the difference between the initial reserves and the total (cumulative) production over the lifetime of the resource. Hence, reserves remaining in period T, R_T are given by Equation (4).

[2] For 1980 and 1990 the value of production (y) is worked out for feldspar as

$y_{1980} = 0\ 0364\ (0) + 3\ 8727 = 3\ 8727$

$y_{1990} = 0\ 0364\ (10) + 3\ 8727 = 4\ 2367$

where, 1980=0 and 1990 = 10

r_p is then calculated as the compound annual growth rate over the period 1980-90, given the above values of production

Hence, $r_p = (y_{1990} / y_{1980})^{(1\ 10)} - 1 = 0\ 0089 = 0\ 009 = 1\%$

Assuming that all of the resource gets exhausted at the end of period T, the right hand side in Equation (4) equals zero and we get Equation (5). In Equation (5), I_0 represents the total recoverable reserves in 1990.

Substituting $Q_t = Q_0 (1+r)^t$ in Equation (5) we get Equation (6). Simplifying this equation further, we get Equation (13), which gives T, the lifetime of the resource.

Calculating Present Value

Substituting the values of T, r_p, Q_0, r, and P_0 we can get PV_0 for the two minerals. The straight line depreciation is then given by PV_0/T. The first year depreciation is given by $PV_0 - PV_1$. The depreciation schedule over the lifetime of the resource can be worked out using ΔV_t the difference, $PV_{t-1} - PV_t$. The average depreciation over the lifetime of the resource is worked out as:

$$\sum_{t=0}^{T} \Delta V_t / T$$

Results

Table A.1 presents the depreciation values, lifetime of the reserves, and the compound annual growth rate of production for feldspar, quartz, and rock phosphate using the present value method The depreciation schedules for the three minerals are represented in Figures A.4-A 6.

Table A.1. Depreciation values, lifetime (T), and compound annual growth rate of production (r_p) for feldspar, quartz, and rock phosphate using the present value method

	T (years)	r_p (percent)	First year depreciation (Rs million)	Straight line depreciation (Rs million)	Average depreciation (Rs million)
Feldspar	29	1	0 025	0.176	0 188
Quartz	38	24	-53	23	12
Rock phosphate	15	24	-254	371	107

As revealed from the depreciation schedule, the value of the asset appreciates till Period 31 for quartz and till Period 10 for rock phosphate. The economic explanation of this appreciation could be that the actual rate of extraction is less than the optimal rate, so that there is no depreciation in the value of the asset.

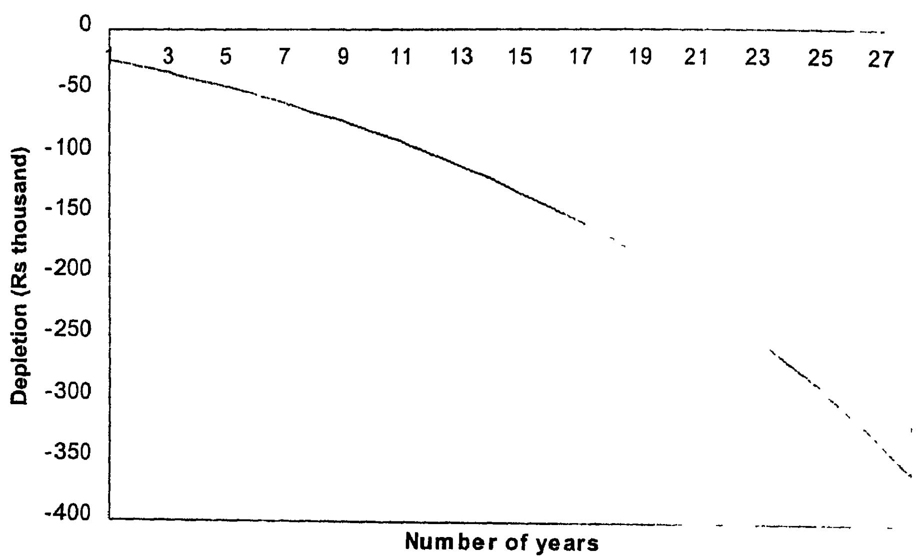

Figure A.4. Depreciation schedule for feldspar

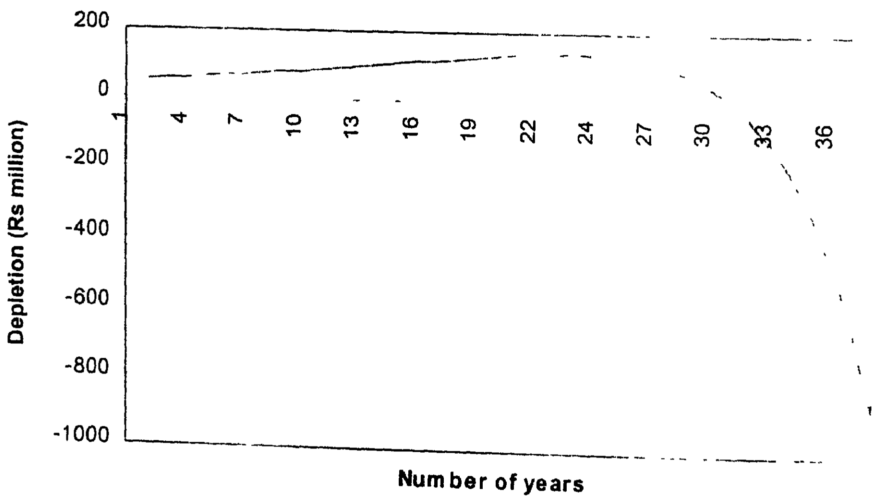

Figure A.5. Depreciation schedule for quartz

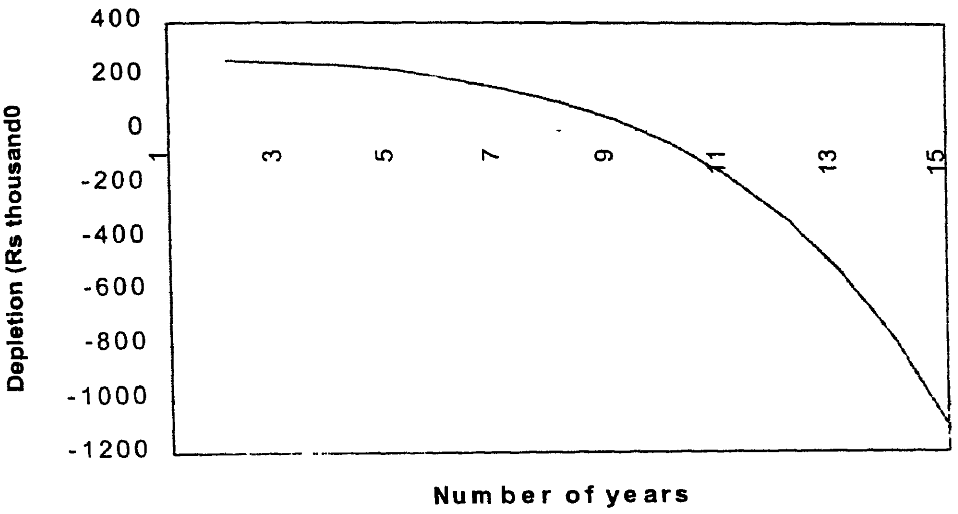

Figure A.6. Depreciation schedule for rock phosphate

Break-up of recoverable reserves, production, and production cost for baryte for 1990.

Table B1. Recoverable reserves of baryte in the Yamuna sub-basin (thousand tonnes)[a]

State	District	Recoverable reserves			
		Proved	*Probable*	*Possible*	*Total*
Himachal Pradesh		nil	9896	2400	12296
	Sirmaur	nil	9896	2400	12296
Rajasthan		3573	726419	1627740	2357732
	Alwar	2771	47491	901922	952184
	Bharatpur	-	-	1260	1260
	Sikar	-	-	50991	50991
Uttar Pradesh		-	-	20000	20000
	Dehradun	-	-	20000	20000
					1036731

Data compiled from the Indian Minerals Yearbook 1992 India Bureau of Mines. Ministry of Steel and Mines. Nagpur

Table B2. Statistics for baryte production in the Yamuna sub-basin[a]

District	*1980*	*1981*	*1982*	*1983*	*1984*	*1985*	*1986*	*1987*	*1988*	*1989*	*1990*
Sirmaur	408	39	213	337	413	933	1428	1010	1090	1102	1512
Alwar	2214	2337	2309	2475	1938	2103	2048	1693	1530	1567	1242
Sikar	12	42	8	2		33	2	2	12	17	7
Total	2634	2418	2530	2814	2351	3067	3478	2705	2632	2686	2761

[a] Data compiled from the Indian Minerals Yearbook 1992 Indian Bureau of Mines. Ministry of Steel and Mines. Nagpur

Table B3. Baryte production cost in the Yamuna sub-basin[a]

District	*1980*	*1981*	*1982*	*1983*	*1984*	*1985*	*1986*	*1987*	*1988*	*1989*	*1990*
Sirmaur	154	154	127	160	160	94	114	104	108	110	120
Alwar	208	295	295	416	427	458	520	538	557	557	657
Sikar	83	95	125	-	-	91	-	-	167	294	429
Total	445	544	546	576	586	643	633	641	832	960	1201
Average	148	181	182	288	293	214	317	321	277	320	402

[a] Data compiled from the Indian Minerals Yearbook 1992 Indian Bureau of Mines Ministry of Steel and Mines Nagpur

APPENDIX C

Annual Return statement[3]

The annual returns for each mine present the data on production, value, consumption of inputs, the depreciation of fixed assets (land, industrial buildings, residential buildings, land and machinery, and transport), other expenses including different sources of finance, wages and salaries, etc. The annual returns provide complete information on the total cost of intermediate consumption, the total production, and the pit mouth value.

Table C1. Annual return statement

	Item	*Value (Rupees thousand)*
1	**Fixed Assets**	
I.	Land	108
II	Industrial buildings	6200
III	Residential buildings	700
IV	Land and machinery, including transport	15300
V	Capitalized expenditure	188
2.	**Source of finance**	
I.	Reserves and surpluses	3.7
II	Long-term loan outstanding	167
3	**Interest and Rent**	
	Interest	5660
4	**Payment made for professional industrial and non-industrial services utilized**	46
5	**Cost of material consumed**	
I	Fuel	
	Coal	3
	Diesel Oil	680
	Gas	15
II	Lubricants	4.5
III.	Electricity consumed	2680
IV	Electricity generated	434
V	Explosives	812
		562
VI	Tyres and timber	150
VII	Drill rods and bits	1517
VIII	Other spares, stores, and office expenses	399
6	**Royalty**	1418
7	**Taxes and cesses**	
	Welfare cess	
I	State Government	68
II	Central Government	
8	**Labour employed and wages paid**	
I	Male	8565
II.	Female	81
9	**Pit mouth value**	Rs 500 per tonne
10.	**Production**	63 500 tonnes

Source Personal communications with officials at Indian Bureau of Mines, Dehradun 1996

To calculate the production cost, the following components from the above annual return statements are incorporated: Depreciation of fixed assets (Depreciation of the sum of

[3] This annexure presents the annual return statement for a rock phosphate mine in Dehradun, as an illustration for the cost components.

Item 1), interest and rent (Item 3), payment made for professional industrial and non-industrial services utilized (Item 4), cost of material consumed (Item 5), labour employed and wages paid (Item 8). The total production cost obtained by adding these items is divided by the total production for that mine (Item 10).

To calculate the pit mouth value, in addition to the above items, the following items are added: Royalty (Item 6) and taxes and cesses (Item 7). Dividing the total so obtained by the production gives the pit mouth value (excluding the profit margin). For the above accounts this value is Rs 500/tonne (which does not include the profit margin).

CHAPTER 10

Results

Tables 10.1–10.13 present the physical and monetary accounts for the thirteen minerals – baryte, calcite, feldspar, iron-ore, kaolin/china clay, rock phosphate, quartz, copper, dolomite, fire clay, gypsum, limestone, and talc/steatite. The depreciation values of the mineral assets are worked out for the minerals using the user cost method and the net price method. Depreciation for the present value method is worked out for rock phosphate, feldspar, and quartz in Appendix A.

Baryte

The opening stock of recoverable reserves increased from 108 000 tonnes in 1980 to 1 million tonnes in 1990. There are large additions to reserves of about one million tonnes over this 10-year period. Production in 1980 as well as 1990 was 3 000 tonnes. This was 0.5% of the all India production (Appendix D).

The monetary value of depletion using the net price method increased from Rs 756 000 to Rs 894 000. There was no significant change in the number of baryte mines in this period. Depreciation using the user cost approach shows some fluctuations in the depreciation till 1984, but on an average, this figure is about Rs 14 000. In 1985, with an upward revision of recoverable reserves and an increase in the lifetime of the reserves, the user cost is zero.

Table 10.1. Physical and monetary accounts for baryte[a]

Accounting category	*1980*	*1981*	*1982*	*1983*	*1984*	*1985*	*1986*	*1987*	*1988*	*1989*	*1990*
Physical accounts											
Opening stock (thousand tonnes)	108	105	103	100	97	771	768.	765	762	759	1037
Production (thousand tonnes)	3	2	3	3	2	3	3	3	3	3	3
Closing stock (thousand tonnes)	105	103	100	97	771	768	765	762	759	1037	
Number of mines	15	16	14	18	18	19	18	20	10	9	10
Monetary accounts											
Production cost (Rs/tonne)	148	181	182	288	293	214	316	321	277	320	402
Pit mouth value (Rs/tonne)	400	400	450	450	500	525	550	480	500	600	700
Net price (Rs/tonne)	252	219	268	162	207	311	234	159	223	280	298
Depreciation											
Net price method (Rs thousand)	756	438	804	486	414	933	702	477	669	840	894
Lifetime (years)	36	53	34	33	49	257	256	255	254	253	346
User cost method (Rs thousand)	13	1	17	12	2	0	0	0	0	0	0

[a] Data on opening stock (recoverable reserves), production , closing stock, and number of mines compiled from 13 volumes (1980–1993) of the Indian Minerals Yearbook. Indian Bureau of Mines. Ministry of Steel and Mines. Nagpur

The data on recoverable reserves is available on five-yearly intervals. Thus, for the intervening periods the recoverable reserves figures have been calculated, as discussed under 'Data' in Chapter 3. For the years 1985 and 1990 these calculated figures do not correspond with the reported data. The opening stock for recoverable reserves in 1985 (closing stock for

1984) is 771 000 tonnes. The calculated figure, however, is 97 000 tonnes. Similarly in 1990, the reported figure is 1 million tonnes, whereas the calculated figure is 759 000 tonnes. This difference could be due to new discoveries, not reported separately.

Calcite

The opening stock in 1980 stood at 108 000 tonnes. By 1990 this figure increased to 127 000 tonnes. The production in 1990 was about 5% of the all India total (Appendix D). The production throughout the period fluctuated around 2 000 tonnes, which implies that there has not been much extraction work in this period. The monetary value of depletion (net price method), however, shows an increase from Rs 442 000 to Rs 1 million over this period. The user cost component shows wide fluctuations, and is Rs 8 996 in 1990.

Eleven mines were reported in 1986. This was the largest number for the period. By 1990 this number had fallen to eight. The discrepancy between the reported and calculated figures of recoverable reserves is not significant for either 1985 or 1990.

Table 10.2. Physical and monetary accounts for calcite[a]

Accounting category	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Physical accounts											
Opening stock (thousand tonnes)	108	106	105	103	102	136	134	132	130	128	127
Production (thousand tonnes)	2	1	2	1	2	2	2	2	2	2	3
Closing stock (thousand tonnes)	106	105	103	102	136	134	132	130	128	127	
Number of Mines	5	8	5	5	9	7	11	9	10	8	8
Monetary accounts											
Production cost (Rs/tonne)	29	44	46	41	71	48	46	70	72	97	100
Pit mouth value (Rs/tonne)	250	275	260	260	260	300	300	325	375	400	450
Net price (Rs/ tonne)	221	231	214	219	189	252	254	255	303	303	350
Depreciation											
Net price method (Rs thousand)	442	231	428	219	378	504	508	510	606	606	1050
Lifetime (years)	54	106	53	103	51	68	67	66	65	64	42
User cost method (Rs)	972	2	1054	2	1168	227	256	288	383	429	8996

[a] Data on opening stock (recoverable reserves), production , closing stock, and number of mines compiled from 13 volumes (1980–1993) of the Indian Minerals Yearbook. Indian Bureau of Mines. Ministry of Steel and Mines. Nagpur.

Feldspar

The opening stock for recoverable reserves in 1980 is 25 000 tonnes. This increased to 127 000 tonnes in 1990. In 1990 the production was 3 000 tonnes, about 4% of all India production. The number of mines recorded were the lowest in 1984 and 1985. In 1990 the total number was eight. The monetary value of depletion under the net price method increased from Rs 85 000 to Rs 219 000 over 1980-90. The user cost falls in the range of Rs 385 000 - Rs 600 000 over 1980-89 and in 1990 this figure is Rs 6000.

The reported figure for recoverable reserves in 1985 is 136 000 tonnes, higher than the calculated figure of 12 000 tonnes. In 1990 the calculated figure is 122 000 tonnes and the reported figure is 154 000 tonnes, the difference not being as significant as that in 1985. This difference could be accounted for by new discoveries.

Iron-ore

In 1990 the total recoverable and geological reserves for iron ore were 3.4 million tonnes and 6 million tonnes, respectively, with a recoverability factor[1] of 57%. The opening stock of iron ore decreased from 4.4 million tonnes in 1980 to 3.4 million tonnes in 1990. The production in 1980 was 8 000 tonnes and increased to 37 000 tonnes in 1990. The relative contribution towards all India production in 1990 was about 0.1%. The number of mines in 1980 were

Table 10.3. Physical and monetary accounts for feldspar[a]

Accounting category	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Physical accounts											
Opening stock (thousand tonnes)	25	25	19	15	12	136	134	131	127	122	154
Production (thousand tonnes)	5	6	4	3	2	2	3	4	5	8	3
Closing stock (thousand tonnes)	25	19	15	12	136	134	131	127	122	154	
Number of mines	5	8	6	9	2	2	9	6	8	9	8
Monetary accounts											
Production cost (Rs/tonne)	48	49	52	62	50	60	54	72	61	54	117
Pit mouth value (Rs/tonne)	65	65	65	75	75	80	110	115	135	175	190
Net price (Rs/ tonne)	17	16	13	13	25	20	56	43	74	121	73
Depreciation											
Net price method (Rs thousand)	85	96	52	39	50	40	168	172	370	968	219
Lifetime (years)	5	3	4	3	4	68	45	33	25	15	51
User cost (Rs thousand)	48	68	33	28	32	0	1	4	22	177	1

[a] Data on opening stock (recoverable reserves), production , closing stock, and number of mines compiled from 13 volumes (1980–1993) of the Indian Minerals Yearbook Indian Bureau of Mines. Ministry of Steel and Mines. Nagpur

only 4 and increased to 13 in 1990. This increase is also reflected in an increase in production over the corresponding years. The monetary value of depletion (net price method) increased quite significantly from Rs 168 000 to Rs 1.5 million over 1980–90. The user cost, on the other hand, is negligible throughout the period. In 1989 it is Rs 184.

For 1985, whereas the calculated figure for the opening stock (closing stock in 1984) is 4.4 million tonnes, the reported figure is 2.1 million tonnes. This difference could be because of downward revisions due to reassessments made by IBM in 1985.

[1] Recoverability factor is defined as total recoverable reserves divided by total geological reserves

Table 10.4. Physical and monetary accounts for iron ore[a]

Accounting category	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Physical accounts											
Opening stock (thousand tonnes)	4440	4432	4426	4415	4401	2110	2086	2047	1991	1955	3627
Production (thousand tonnes)	8	6	11	14	12	24	39	56	36	44	37
Closing stock (thousand tonnes)	4432	4426	4415	4401	2110	2086	2047	1991	1955	3627	
Number of mines	4	6	9	10	9	10	14	14	16	15	13
Monetary accounts											
Production cost (Rs/tonne)	18	19	24	52	59	52	60	58	59	74	67
Pit mouth value (Rs/tonne)	39	39	49	49	49	55	62	64	66	101	108
Net price (Rs/tonne)	21	20	25	-3	-10	3	2	6	7	27	41
Depreciation											
Net price method (Rs thousand)	168	120	275	-42	-120	72	78	336	252	1188	1517
Lifetime (years)	555	739	402	315	367	88	53	37	55	44	98
User cost (Rs)	0	0	0	0	0	0	5	91	14	184	1

[a] Data on opening stock (recoverable reserves), production , closing stock, and number of mines compiled from 13 volumes (1980–1993) of the Indian Minerals Yearbook. Indian Bureau of Mines. Ministry of Steel and Mines. Nagpur

Similarly, for 1990 the reported figure is 3.6 million tonnes and the calculated figure is 1.9 million tonnes. Another problem in these accounts is that the net price for 1983 and 1984 is negative.

Kaolin/ China clay

The recoverability factor for Kaolin is 82%. The opening stock in 1980 and 1990 was 11.4 million tonnes and 12 million tonnes, respectively. The depletion, in physical units, was 78 000 tonnes in 1980 and 104 000 tonnes in 1990. The monetary value of depletion using the net price method went up from Rs 29 million to nearly Rs 1 billion over this period. However, the user cost is zero.

The data on the opening stock of recoverable reserves for 1985 as reported by the Indian Bureau of Mines is 11.6 million tonnes. The corresponding calculated stock is 11.2 million tonnes. In this case, therefore, the difference is not significant. For 1990 the corresponding figures are 12 million tonnes and 11.3 million tonnes respectively.

Table 10.5. Physical and monetary accounts for kaolin/china clay[a]

Accounting category	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Physical accounts											
Opening stock (thousand tonnes)	11464	11386	11307	11220	11150	11650	11564	11487	11394	11326	11998
Production (thousand tonnes)	78	79	87	70	54	86	77	93	68	109	104
Closing stock (thousand tonnes)	11386	11307	11220	11150	11650	11564	11487	11394	11326	11998	
Number of mines	20	20	23	25	19	15	16	18	21	19	18
Monetary accounts											
Production cost (Rs/tonne)	25	24	20	23	35	34	34	37	42	53	54
Pit mouth value (Rs/tonne)	400	400	420	420	450	450	450	645	645	900	1000
Net price (Rs/ tonne)	375	376	400	397	415	416	416	608	603	847	946
Depreciation											
Net price method (Rs thousand)	29250	29704	34800	27790	22410	35776	32032	56544	41004	92323	98384
Lifetime (thousand years)	147	144	130	160	206	135	150	124	168	104	115
User cost (Rs)	0	0	0	0	0	0	0	0	0	0	0

[a] Data on opening stock (recoverable reserves), production , closing stock, and number of mines compiled from 13 volumes (1980–1993) of the Indian Minerals Yearbook. Indian Bureau of Mines. Ministry of Steel and Mines. Nagpur.

Rock phosphate

The total recoverable reserves fell from 25.3 million tonnes to 18.6 million tonnes over 1980–90. The production in 1980 was 6 300 tonnes and increased to 133 000 tonnes by 1990 (about 20% of the all India production). The corresponding values for monetary depletion (net price method) were Rs 16.8 million and Rs 104 million, respectively. This is a very substantial increase, largely on account of an increase in the pit mouth value (Rs 420/tonne in 1980 as opposed to Rs 1021/tonne in 1990—143% increase), without an equivalent increase in the production cost (Rs 153/tonne to Rs 253/tonne—65% increase) causing a large increase in the net price over this period. The user cost, however, is zero over 1980-85, and increases to Rs 23 in 1986, when there is a downward revision of recoverable reserves. In 1989 this figure increases to Rs 14 216. But, in 1990 it once again shows a decline and falls to Rs 14. This is also on account of a downward revision of reserves in 1990 by the IBM. The number of rock phosphate mines in this region are 2, and there was no change in this number over the period.

The calculated figure for the opening stock of recoverable reserves is 25.1 million tonnes, whereas the reported data is 11.5 million tonnes in 1985. For 1990 the calculated figure is 11 million tonnes as opposed to the actual data of 18.6 million tonnes as reported by the Indian Bureau of Mines. For both the years this difference could be accounted for by the downward revision of reserves by IBM due to reassessment and re-classification of mineral resources.

Table 10.6. Physical and monetary accounts for rock phosphate[a]

Accounting category	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Physical accounts											
Opening stock (thousand tonnes)	25370	25307	25245	25179	25122	11554	11459	11335	11198	11061	18629
Production (thousand tonnes)	63	62	66	57	80	95	124	137	137	140	133
Closing stock (thousand tonnes)	25307	25245	25179	25122	11554	11459	11335	11198	11061	18629	
Number of Mines	2	2	2	2	2	2	2	2	2	2	2
Monetary accounts											
Production cost (Rs/tonne)	153	152	155	158	170	199	203	185	185	236	233
Pit mouth value (Rs/tonne)	420	. 420	430	440	440	440	450	729	748	1021	1021
Net price (Rs/tonne)	267	268	275	282	270	241	247	544	563	785	788
Depreciation											
Net price method (Rs thousand)	16821	16616	18150	16074	21600	22895	30628	74528	77131	109900	10480 4
Lifetime (years)	403	408	383	442	314	122	92	83	82	79	140
User cost method (Rs)	0	0	0	0	0	23	908	6127	7102	14216	14

[a] Data on opening stock (recoverable reserves), production , closing stock, and number of mines compiled from 13 volumes (1980–1993) of the Indian Minerals Yearbook. Indian Bureau of Mines. Ministry of Steel and Mines. Nagpur.

Quartz

There was a significant increase in recoverable reserves from 28.5 million tonnes to 208 million tonnes over 1980–90. The production in 1980 was 8 000 tonnes and doubled to 16 000 tonnes in 1990 (6% of all India production). Using the net price method, the monetary value of depletion showed an increase from Rs 216 000 to Rs 304 000 over this period. The user cost is zero.

The discrepancy in the reported and calculated figures for recoverable reserves in 1985 is as high as 113 million tonnes. For 1990 this difference is 66 million tonnes. This difference could be accounted for by new discoveries.

Table 10.7. Physical and monetary accounts for quartz[a]

Accounting category	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Physical accounts											
Opening stock (thousand tonnes)	28560	28552	28546	28541	28537	142176	142171	142163	142154	142145	208399
Production (thousand tonnes)	8	6	5	4	4	5	8	9	9	10	16
Closing stock (thousand tonnes)	28552	28546	28541	28537	142176	142171	142163	142154	142145	208399	
Number of mines	14	15	15	20	16	19	23	25	24	25	29
Monetary accounts											
Production cost (Rs/tonne)	29	29	37	28	35	41	33	33	39	35	56
Pit mouth value (Rs/tonne)	56	56	56	56	60	60	65	65	65	75	75
Net price (Rs/tonne)	27	27	19	28	25	19	32	32	26	40	19
Depreciation											
Net price method (Rs thousand)	216	162	95	112	100	95	256	288	234	400	304
Lifetime (years)	3570	4759	5709	7135	7134	28435	17771	15796	15795	14215	13025
User cost (Rs)	0	0	0	0	0	0	0	0	0	0	0

[a] Data on opening stock (recoverable reserves), production , closing stock, and number of mines compiled from 13 volumes (1980–1993) of the Indian Minerals Yearbook. Indian Bureau of Mines Ministry of Steel and Mines. Nagpur

Copper

In 1980 the opening stock was 93 million tonnes. A significant decline took place in 1985 when the reported reserves fell to 53 million tonnes. This was primarily due to the reclassification of reserves by the Indian Bureau of Mines in 1985, whereby downward revision of reserves was made. In 1990 there is an upward revision of reserves, possibly due to new discoveries, when the total reserves reported are of the order of 90 million tonnes (35% of all India production). The net price (and, therefore, the depletion value) is negative for a number of years. Copper mines fall under the public sector and the ore is not directly sold in the market. The data on the average pit head price (average of the value of the ore for all grades in the country, where the value of the ore is the production times the pit mouth value) is also not a good proxy in this case since it is lower than the production cost. Thus, the depreciation values have not been worked out.

Table 10.8. Physical and monetary accounts for copper[a]

Accounting category	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Physical accounts											
Opening stock (million tonnes)	93	92	91	90	89	53	52	50	48	47	90
Production (million tonnes)	0.8	0.8	0.6	1	1.3	1.5	1.6	1.7	1 8	1.8	1 8
Closing stock (million tonnes)	92	91	90	89	53	52	50	48	47	90	
Number of mines	4	4	2	4	4	4	4	4	4	4	4
Monetary accounts											
Production cost (Rs/tonne)	145	188	228	225	212	208	255	286	325	425	380
Pit mouth value (Rs/tonne)	164	202	182	193	199	214	210	215	239	251	262
Net price (Rs/tonne)	19	14	-46	-32	-13	6	-45	-71	-86	-174	-118

[a] Data on opening stock (recoverable reserves), production , closing stock, and number of mines compiled from 13 volumes (1980–1993) of the Indian Minerals Yearbook. Indian Bureau of Mines Ministry of Steel and mines Nagpur

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Dolomite

The total stock of reserves in 1980 was 121 million tonnes; by 1990 this had declined to 53 million tonnes. Correspondingly, there is a fall in the production from 13 000 tonnes to 3 000 tonnes (0.1% of the all India production) over the same period. The corresponding depletion values (net price method) were Rs 576 in 1980 and Rs 247 in 1990, which are very low figures. The user cost approach shows zero depreciation over the entire period. In these accounts, the average pit head price for the country has been used instead of the pit mouth value as the pit mouth values for different years were lower than the corresponding production costs.

Fire clay

The opening stock of reserves in 1980 was 113 000 tonnes and increased to 2 million tonnes by 1990. The corresponding production figures are 6 000 tonnes and 1 tonne (0.2% of all India production). The pit mouth value figures are lower than those for production costs and the average pit head price is not available. Due to inconsistency in data the depletion value has not been calculated.

Table 10.9. Physical and monetary accounts for dolomite[a]

Accounting category	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Physical accounts											
Opening stock (thousand tonnes)	121360	121347	121334	121310	121292	83428	83420	83413	83408	83406	53677
Production (thousand tonnes)	13	13	24	18	17	8	7	5	2	3	3
Closing stock (thousand tonnes)	121347	121334	121310	121292	83428	83420	83413	83408	83406	53677	
Number of mines	10	11	11	11	9	10	9	10	9	7	6
Monetary accounts											
Production cost (Rs/tonne)	10	18	19	21	25	27	30	29	22	40	66
Pit mouth value (Rs/tonne)	41	41	50		30	30	25	25	30	30	30
Average pit head price (Rs/tonne)	44	46	51	56	66	67	66	69	86	82	82
Net price (Rs/tonne)	34	28	32	35	41	40	36	40	64	42	16
Depreciation											
Net price method (Rs thousand)	576	600	1215	1007	1115	534	461	344	173	246	247
Lifetime (years)	9336	-	-	-	-	-	-	-	-	-	-
User cost (Rs)	0	-	-	-	-	-	-	-	-	-	-

[a] Data on opening stock (recoverable reserves), production , closing stock, and number of mines compiled from 13 volumes (1980–1993) of the Indian Minerals Yearbook Indian Bureau of Mines Ministry of Steel and Mines. Nagpur.

Table 10.10. Physical and monetary accounts for fire clay[a]

Accounting category	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Physical accounts											
Opening stock (thousand tonnes)	113	107	101	93	88	204	200	198	197	195	2000
Production (thousand tonnes)	6	6	8	5	5	4	2	1	2	1	1
Closing stock (thousand tonnes)	107	101	93	88	204	200	198	197	195	2000	-
Number of mines	4	7	7	4	5	3	3	6	5	4	5
Monetary accounts											
Production cost (Rs/tonne)	36	29	21	32	38	41	44	57	69	41	38

[a] Data on opening stock (recoverable reserves), production , closing stock, and number of mines compiled from 13 volumes (1980–1993) of the Indian Minerals Yearbook. Indian Bureau of Mines. Ministry of Steel and Mines. Nagpur.

Gypsum

The total reserves in 1980 were about 1 million tonnes and increased to 2 million tonnes by 1990. The corresponding production figures are 3 000 tonnes and 1 000 tonnes (about 0.1% of all India production). The number of mines was also stable through the period. The pit mouth value is less than the production cost in a number of years. The average pit head price is also lower. Thus, the depletion value has not been calculated. For 1990 the discrepancy between the reported figure for the opening stock of reserves and the calculated figure for closing stock in 1989 is quite wide—1 million tonnes as opposed to 2 million tonnes. This is possibly due to new discoveries.

Limestone

The total reserves are very large—1.2 billion tonnes in 1980 and 3.6 billion tonnes in 1990. Production in 1980 was 1.6 million tonnes and in 1990 it was 2.1 million tonnes (3% of all India production). A large number of limestone mines fall in the public sector and the price of the ore (the pit mouth value) is administered, which explains why the pit mouth value is often lower than the production cost. Thus, the net price and the monetary value of depletion is negative for some years and the depreciation values have not been calculated.

Table 10.11. Physical and monetary accounts for gypsum[a]

Accounting category	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Physical accounts											
Opening stock (thousand tonnes)	1346	1343	1342	1338	1331	1325	1323	1318	1312	1309	2263
Production (thousand tonnes)	3	0.7	4	7	8	2	5	6	3	0.3	1
Closing stock (thousand tonnes)	1343	1342	1338	1331	1323	1323	1318	1312	1309	1309	2262
Number of mines	1	1	1	1	1	1	1	1	1	1	1
Monetary accounts											
Production cost (Rs/tonne)	44	43	52	100	100	100	70	76	86	74	-
Pit mouth value (Rs/tonne)	50	55	60	60	65	70	48	60	60	86	98

[a] Data on opening stock (recoverable reserves), production , closing stock, and number of mines compiled from 13 volumes (1980–1993) of the Indian Minerals Yearbook. Indian Bureau of Mines. Ministry of Steel and Mines. Nagpur

Table 10.12. Physical and monetary accounts for limestone[a]

Accounting category	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Physical accounts											
Opening stock (million tonnes)	1216	1214	1212	1210	1208	1596	1594	1591	1590	1588	3634
Production (million tonnes)	1.6	1.8	2	2.6	2.4	2.2	2.4	1.5	2.1	1.9	2.1
Closing stock (million tonnes)	1214	1212	1210	1208	1596	1594	1591	1590	1588	3634	-
Number of mines	48	44	46	50	45	56	45	45	43	39	34
Monetary accounts											
Production cost (Rs/tonne)	27	26	31	35	39	40	45	51	58	62	68
Pit mouth value (Rs/tonne)	-	31	31	31	36	36	45	45	45	66	72
Average pit head price (Rs/tonne)	26	27	32	36	38	40	42	46	47	57	45

[a] Data on opening stock (recoverable reserves), production , closing stock, and number of mines compiled from 13 volumes (1980–1993) of the Indian Minerals Yearbook. Indian. Bureau of Mines. Ministry of Steel and Mines. Nagpur.

Talc/Steatite

The reserves in both 1980 and 1990 were about 10 million tonnes. Production in 1980 was 56 000 tonnes and increased to 69 000 tonnes in 1990. The depletion value in 1980 is calculated at Rs 3 million and in 1990 at nearly Rs 4 million, using the net price method. The user cost, on the other hand, shows no depreciation for most of the period, and for 1989 it shows a low figure of Rs 19. In 1985 there is a downward revision in reserves and user cost shows a minuscule increment of Rs 2 for the following year. In 1989, this figure is Rs 19 due to some

increase in the production. In 1990 there is an upward revision of reserves and once again the user cost falls to zero.

Table 10.13. Physical and monetary accounts for talc/steatite[a]

Accounting category	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Physical											
Opening stock (thousand tonnes)	10073	10017	9957	9905	9857	7428	7371	7312	7263	7222	9931
Production (thousand tonnes)	56	60	52	48	51	57	59	49	41	66	69
Closing stock (thousand tonnes)	10017	9957	9905	9857	7428	7371	7312	7263	7222	9931	
No of mines	23	25	27	25	26	29	31	34	28	23	23
Monetary											
Production cost (Rs/tonne)	57	70	64	71	87	115	110	125	112	224	278
Pit mouth value (Rs/tonne)	261	261	301	301	140	140	140	150	550	600	600
Net price (Rs/ tonne)	204	191	237	230	53	25	30	25	438	376	322
Depreciation											
Net price method (Rs thousand)	3136	3600	2704	2304	2601	3249	3481	2401	1681	4356	4761
Lifetime (years)	180	167	191	206	193	130	125	149	177	109	144
User cost (Rs)	0	0	0	0	0	1	2	0	0	19	0

[a] Data on opening stock (recoverable reserves), production , closing stock, and number of mines compiled from 13 volumes (1980–1993) of the Indian Minerals Yearbook. Indian Bureau of Mines. Ministry of Steel and Mines Nagpur

APPENDIX D

Share of the Yamuna sub-basin in total Indian mineral production in 1990

Table D.1. Share of the Yamuna sub-basin in total Indian mineral production[a]

Mineral	*Percentage share*
Rock phosphate	19.5
Baryte	0 5
Calcite	4.8
Copper	35
Dolomite	0.12
Feldspar	4
Fireclay	0.2
Gypsum	0.1
Iron ore	0.1
Kaolin	16
Limestone	3
Quartz	6
Talc	15.5

[a] Data compiled from the *Indian Minerals Yearbook 1993*. Nagpur: Indian Bureau of Mines Ministry of Steel and Mines and *Growth of Indian mineral industry since independence (1947–1991)*. Nagpur: Indian Bureau of Mines. Mineral Statistics Division Ministry of Mines Government of India. Feb. 1992.

Discussion

Recoverable reserves

There is a discrepancy between the calculated and actual figures of reserves (1984 as compared to 1985 and 1989 as compared to 1990) on account of the fact that IBM reassesses resources at five yearly intervals. In addition, the classification of reserves was changed in 1985. Prior to 1985, a reserve was inventorized on the basis of the availability of mineral resources on techno-economic grounds. Since 1985, a resource not extractable on techno-economic and environmental grounds is not regarded as a reserve. For all practical purposes, in this study it is assumed that in cases where the reported figure is less than the calculated figure, this is due to a downward revision of reserves due to reassessment and reclassification, whereas in cases where the reported figure is higher it is assumed that the difference is due to discoveries, which are not reported separately.

Discoveries

The IBM does not report data explicitly on new discoveries. Upward or downward adjustments in reserves due to new information and changes in technological and economic conditions are not reported, though these adjustments are made by the IBM when reporting data on recoverable reserves at five-yearly intervals. Thus, the accounts only present data for production. Ideally, the accounting identity should be:

```
Closing stock = Opening stock + reserve accretion - reserve
                                              depletion (4)
```

where, reserve accretion incorporates increases in reserve estimates due to new discoveries or changes in technology and reserve depletion includes production (extraction), destruction, and diminution. The accounting identity we have used in this study is:

```
Closing stock = Opening stock - production                    (5)
```

This identity has an implicit assumption that accretion due to discoveries is accounted for in the opening stock figure.

The price dilemma

There is an inconsistency in the prices used in the study. The price we have used for the monetary valuation of the reserves is the pit mouth value. In a few cases, the transportation cost (from mine pit to loading point) is included in the pit mouth value. Other alternatives are

border prices (export price or import price), which reflect the opportunity cost of the ore. In case of some minerals, as discussed above, the average pit head price[1] has been used in place of pit mouth value.

The international price (export price or import price) for the ore has not been used for monetary valuation as this study is confined to the Yamuna sub-basin and the use of pit mouth values is preferred over border prices. These are assumed to represent the true value of the mineral resource. Apart from this fact, there is also no information available on the import and export status of ores from the Yamuna sub-basin.

Figures E1–E12 (Appendix E) show the trend in export price, import price, production cost, and pit mouth value over the period 1980–90 for the minerals found in the Yamuna sub-basin. These figures show that the border prices are significantly higher than the pit mouth values. This could be on account of the superior quality of the ores exported/imported. This, too, reflects the fact that international prices are not the best option to value mineral resources in this study.

In case of some minerals the production cost is reported as the pit mouth value. Ideally the pit mouth value represents the sale of the ore at the pit head. But, in case of captive mines, this is not calculated and the mines falling in this category extend the production costs to the Indian Bureau of Mines (IBM). Non-captive mines provide the selling price of the mineral to IBM, but as these documents are accessible to the public and this information is sensitive, the owners do not reveal the actual pit mouth value. In these cases, too, therefore, the pit mouth value often coincides with the production cost.

Future scope of work

No estimates have been made for environmental damage costs. Mineral exploration and extraction process causes deforestation, soil erosion, land damage, lowering of the ground water levels, deterioration in air and water quality and also affects the socio-economic status. Thus, attempts ought to be made towards obtaining a comprehensive picture of all such damages by accounting for these environmental costs.

The valuation exercise undertaken in this study should be extended to the country as a whole to get a better picture of mineral depletion. In that case, border prices could be used for monetary valuation, rather than the pit mouth values.

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[1] The average pit head price of a mineral ore is the average of the pit head price reported over the entire country for different grades of the ore.

Appendix E: Trend in prices

Figure E.1. Rock phosphate prices

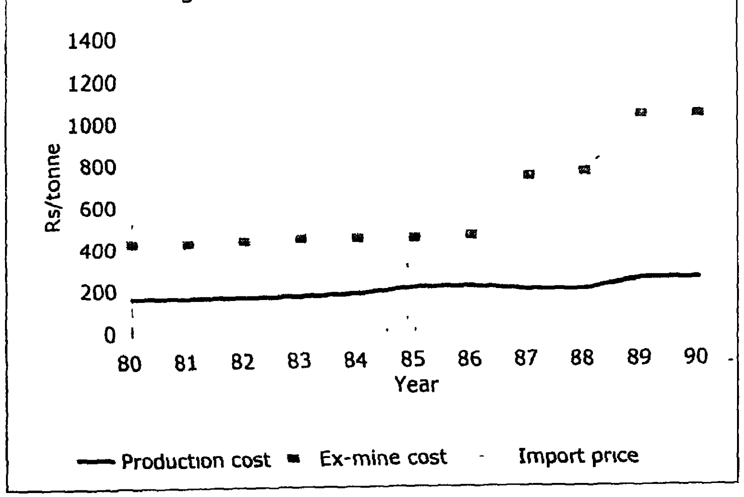


Figure E.2. Baryte prices

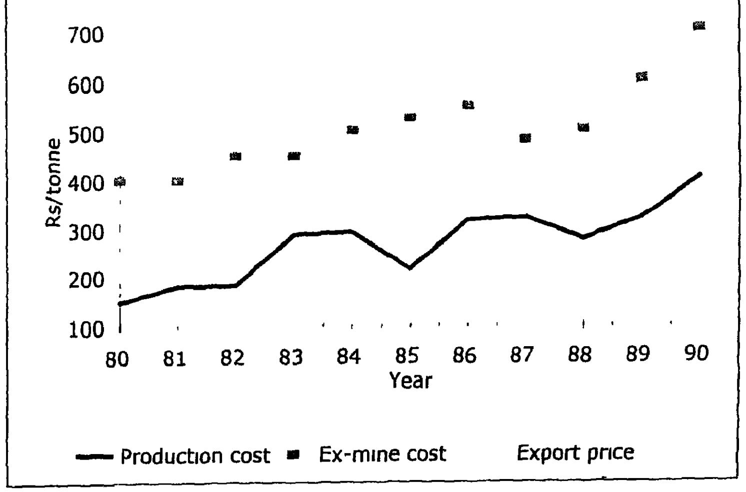


Figure E.3. Calcite prices

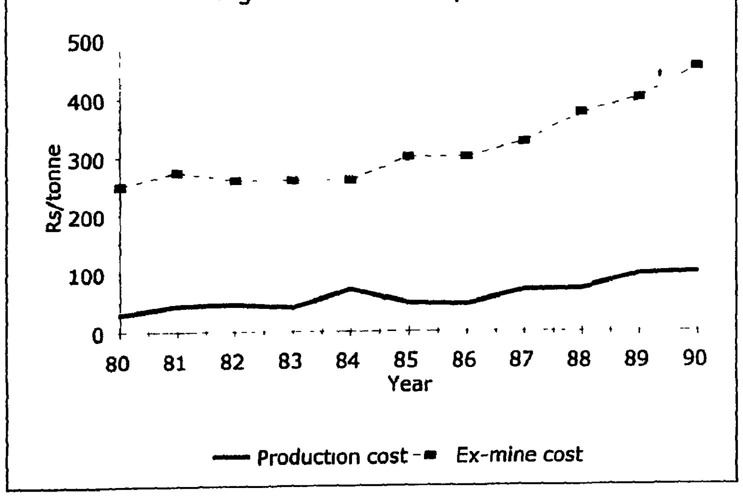


Figure E.4. Copper prices

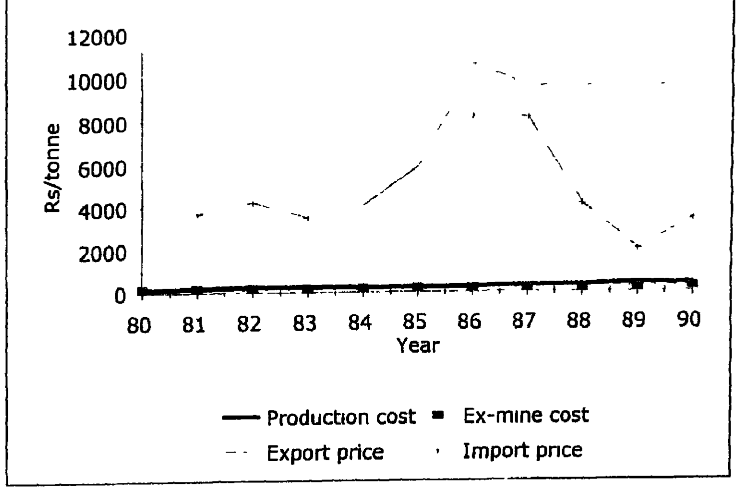


Figure E.5. Feldspar prices

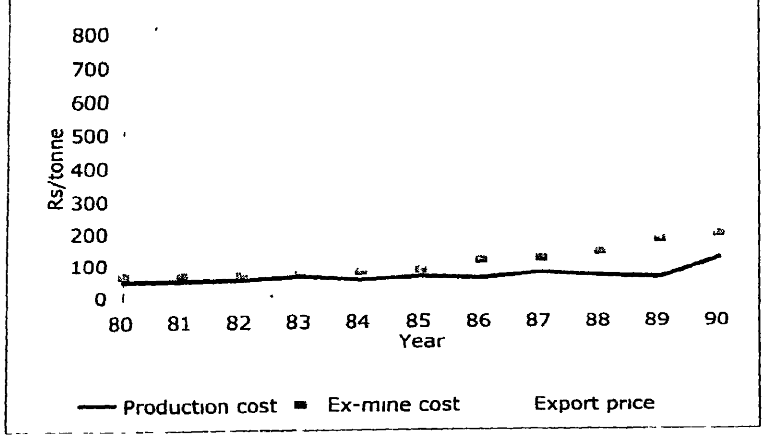


Figure E.6. Fireclay prices

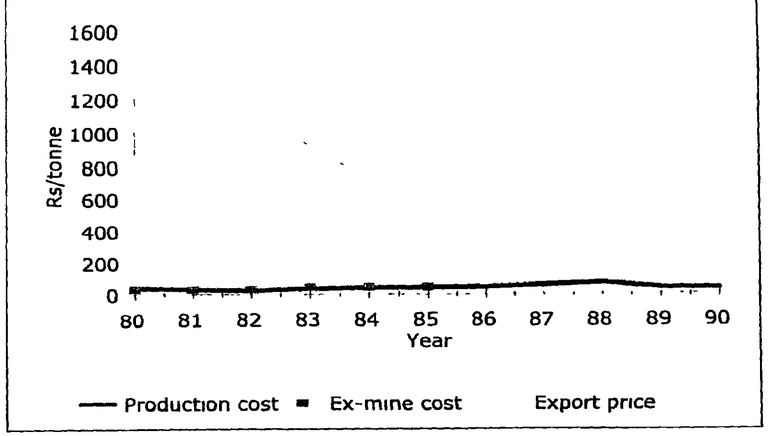


Figure E.7. Gypsum prices

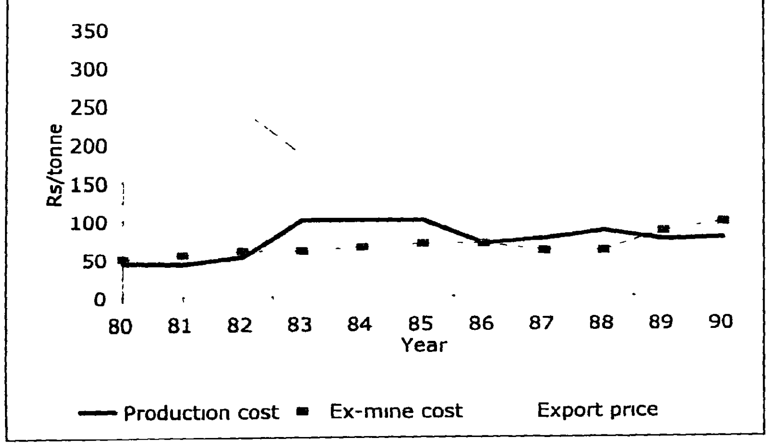


Figure E.8. Iron ore prices

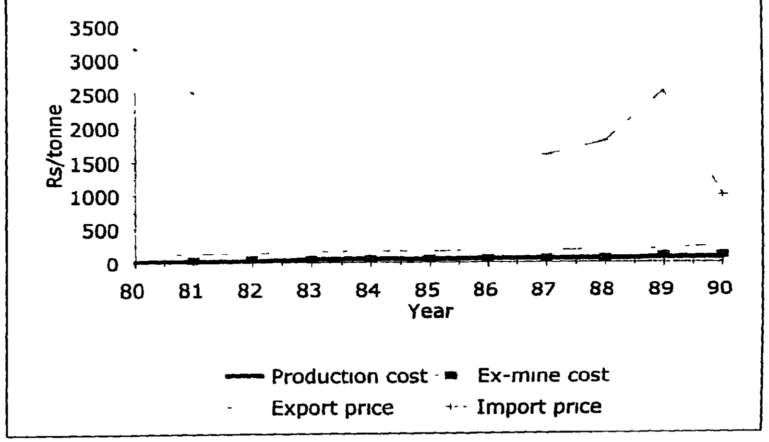


Figure E.9. Kaolin prices

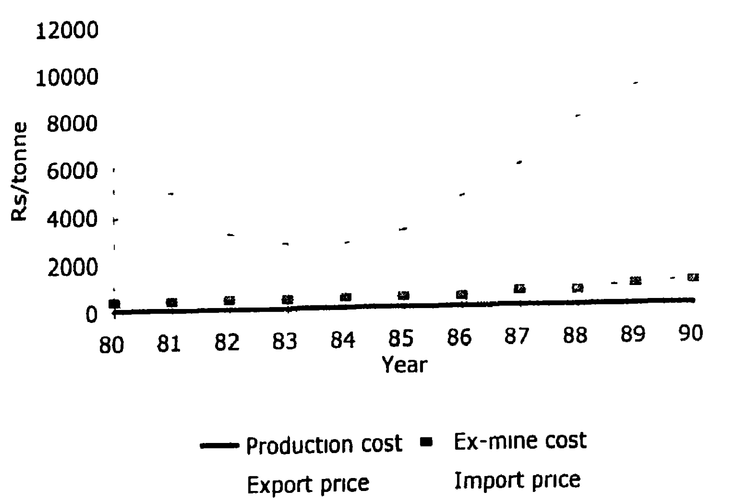


Figure E.10. Limestone prices

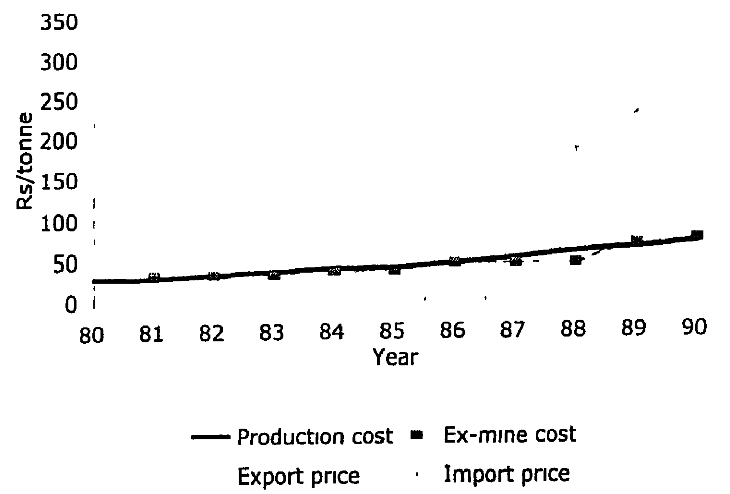


Figure E.11. Quartz prices

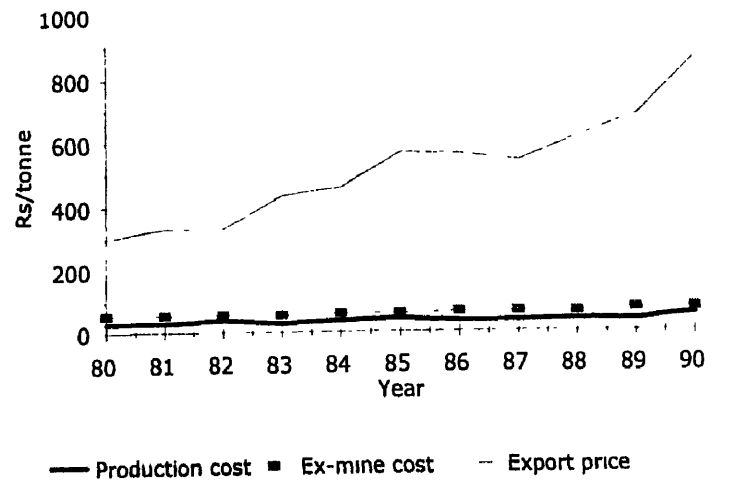
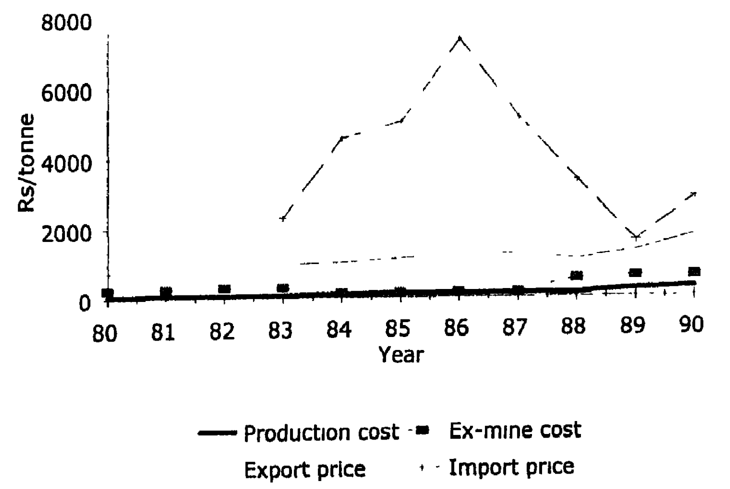


Figure E.12. Talc/steatite prices



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SECTION 3

Exposures to air pollution and health

Raj Kumar Prasad, Ravi Shankar and Sumeet Saksena

CHAPTER 12

Introduction

Objectives

The objectives of the study are to assess the exposure to and health impacts of air pollution in the Yamuna river sub-basin. To meet these objectives, the underlined steps were followed.

- Time-budget and health survey of various population groups of the study area based on activity, gender and age.

- Determination of air pollution level for micro-environments.

- Calculation of daily integrated exposure and population exposure for the identified population groups, district-wise.

- Analysis of health data generated from the health survey and collation of secondary information on health.

Exposure

Most studies on urban and regional environment are concerned with the physical indicators for determining environmental quality. For instance, air quality is usually determined by a network of fixed monitoring stations. But it does not provide a fair estimate of what people breathe, in other words, what is their exposure? Similarly certain groups of people who live or work in certain areas are either exposed to a higher or lower concentration of pollutants than the ambient air. The ambient air quality measurements alone are not fair indicators of the exposure risk in cities with different climatic conditions, industrial units, socio—economic conditions, and lifestyles.

Health impacts

All illness can, in theory, be caused by either genetic factors or environmental factors. Environmental factors are of different types — chemical, physical, biological, psychological and safety factors. The concept of "environmental disease" is usually applied to illnesses from chemical exposures due to the environmental pollution, but it could be used for any health problem which is caused by an environmental factor. The health effects of environmental factors may be influenced by any of the above factors. Exposure to a given pollutant is a measure of the contact between the pollutant and the outer or inner surface of the human body. Thus, air pollution exposure estimation is the determination of the concentrations of air pollutants in the inhaled air as a function of time and space coordinates, in which the space coordinate define the position of the exposed individual, particularly his nose and mouth.

Dose, on the other hand, is the amount of air pollutant that crosses one of the body boundaries.

Epidemiological studies have consistently shown an association between particulate air pollution and not only exacerbation of illness in people with respiratory diseases but also a rise in the number of deaths from cardiovascular and respiratory diseases among older people. Epidemiological research over the last few years has provided additional evidence on the health effects of air pollution and provides a rich basis for predicting several adverse outcomes associated with exposure to air pollution.

Air monitoring and epidemiological studies have explained that air pollution levels in developed countries have declined noticeably in recent years. Current research trends showed that elsewhere, air pollution levels and associated negative health impacts are increasing. Indeed, in many developing countries, air pollution levels now exceed by a considerable amount the levels considered safe in developing countries. Increased morbidity and mortality can be caused by a wide range of environmental stress that are often correlated with each other. The long term effects of cumulative life time exposure may represent a more important public health risk than an isolated air pollution episode. Review of routinely collected public health records revealed a three fold increase in sulphur dioxide and particulate air pollution concentrations. These incidents had many similarities to and infectious diseases out break. Air pollutants have been shown to cause responses ranging from reversible changes in respiratory systems and lung functions, changes in air way reactivity and inflammation, structural remodeling of pulmonary air ways, and impairment of pulmonary host defenses, to increased respiratory morbidity and mortality.

Women and infants are the most vulnerable group, poor nutrition, lack of health care increases the incidence of disease in human population. House hold cooking and open fire has been described as the largest single occupational health problem of women in the world. Biomass fuels are the primary fuels for most domestic users in poor communities. They include wood, animal dung and crop residues. The use of the biomass fuels causes most of the health hazards in women and children. Women and children are especially vulnerable to the heavy concentrations of smoke in unventilated cooking areas from both wood and dung cake used as cooking fuel. The exposure to this smoke causes chronic eye irritation, bronchitis and serious respiratory ailments. In case of infants the health impacts would be more serious due to the existing malnutrition. Health impacts are given below.

- Exposure to smoke causes respiratory and eye irritation and associated diseases.
- Chronic obstructive lung disease.
- Heart disease, especially corpulmonale.
- Acute respiratory infections, particularly in children.

- Eye disorders like conjunctivitis, and blindness.
- Cancer, lung cancer due to long term exposure to smoke.

Most of the air pollutants do not lead to specific diseases, but depending on the pollutant, the concentration and the duration of exposure, some organs are more affected than others. The most frequent disorders are those caused by irritant gases and particulate on the mucous membrane and other respiratory organs. The consequences are eye, nose and throat inflammation, diminished lung function, increased susceptibility to respiratory infection and higher incidence of chronic bronchitis. These disorders and diseases are of course influenced by other factors as well, such as immune deficiency, allergies, occupational exposure to pollutants and particularly smoking. Effects of air pollutants are therefore, multi factorial conditioned and non specific disorders are placed in the foreground. The epidemiologist must therefore estimate not only the association between exposure and disease, but also consider alternative explanations for observations.

Particulate matter, some times referred to as dust or soot, affects the entire population. Particulate matter is a heterogeneous mixture of chemicals directly emitted into the air from the various sources like industrial manufacturing processes, transport, domestic and agricultural sources. This particulate matter comprises of particles of various sizes ranging from 10 µm or less in diameter. The smaller and fine particulate matter is of greater health concern than the particulate of larger size, since they are more likely to penetrate into the deep lung. High levels of particulate cause many airborne infection in people who live in over crowded dwellings. Acute respiratory infections, tuberculosis, pneumonia and influenza are all common.

CHAPTER 13

Study area

The entire study area is a part of five states, viz., entire state of Delhi, almost all of Haryana, parts of western Uttar Pradesh, southern districts of Himachal Pradesh and northern districts of Rajasthan.

Delhi

It is estimated 2.5 lakh persons move to the city every year in search of employment. Due to the space constraints, population started living in the slum areas under very deplorable and sub human conditions. Contaminated water and poor sanitation, cause serious health problems to the population. The city experiences epidemics and other contagious diseases with frightening regularity. Epidemic emergencies have been striking a capital city with increasing severity since last few years.

The emissions from the vehicles, thermal power plants, industries and domestic coal burning are the main contributors to the poor air quality of the city. An estimated 2000 metric tones of pollutants are emitted into the atmosphere every day in Delhi. Carbon monoxide (CO) topped the list of pollutants with an estimated emission of 1063 metric tones per day followed by nitrogen dioxide 323, hydro carbon's 320 and sulphur dioxide 179 metric tones. Vehicular sources contribute about 64% of total pollutants emitted followed by thermal power plants 16%, industry 12% and domestic sector 7%.

Urban air pollution is worsening due to upward trends in power consumption, industrialization, and vehicle ownership and uses, and refuses burning. The quality of air can lead many respiratory illnesses ranging from a simple allergy and infections to cancer of the lung and other organs. Air pollutants have been shown to cause responses ranging from reversible changes in the respiratory systems and lung function, changes in airway reactivity and inflammation, structural remodeling of pulmonary airways, and impairment of pulmonary host defenses, to increased respiratory morbidity and mortality. Most air pollutants do not lead to specific diseases. Depending on the concentration and duration of exposure, some organs are more affected than others. The most frequent disorders observed during the study were eye, nose irritation, throat inflammations diminished lung function and increased susceptibility to the respiratory infection and higher incidence of chronic bronchitis.

Other area

The socioeconomic level of a state is directly reflected not only in their social, cultural and economic status of its people but also in their health status. There is a direct interrelationship between socioeconomic development and health status. Greater the socioeconomic development of a state the better is the health status of its people. The reasons for low health status of the people of the state are multi - faceted. The first is poverty.

Health conditions are very poor and the morbidity rates remain high. The high rate of population growth continues to affect the health of the people and the quality of their life. Higher death rate and infant mortality rates coupled with lower life expectancy, showed that more attention is needed in the region to strengthen the delivery general health, deficiencies and communicable diseases, man made diseases, i.e., exploitation of child labor, over burdening of women because of male migration to urban areas. There fore the problem of health in these states should be looking at in social needs and be related to social inequalities.

Industrialization may create several health hazards to the population, because of pollution. Health hazards due to nuclear radiation, mining can pose lots of health problems in future. All these workers are exposed various pollutant's leads to diseases like silicosis, asbestosis, pneumokoniosis, tuberculosis and cancer. There is no remedy for the various kinds of pneumoconiosis. Thousands of workers working in mines of soapstone, talc, slate, asbestos, mica etc are exposed to high levels of respirable dust, which effects them in the long run. Some major portions of this worker are working in crushers, grinders. Exposure to this dust may develop silicosis in a very short time. Whenever there is monsoon failure, the agricultural labor is forced to take up work in the mining sector.

Drought and flood situation in the states, forcing people for a mass migration to urban industrial areas like Punjab, Delhi, Bombay and Calcutta for seeking employment. People were severely affected by the continuous drought in certain areas, causing severe malnutrition and even starvation deaths. In case of a flood affected areas' occurrences of gastro-intestinal infections such as diarrhoea, dysentery, cholera. , Typhoid and viral hepatitis is very high. Four major environmental factors those effect healths are water supply, sanitation housing and ecological degradation. Most of the industrial units continue to discharge their wastes into the environment this in turn affects the drinking water bodies. Air pollution considerably increased in urban area, due to industrial activities, automobiles and the mining sector. High incidences of asthma in children are reported to be suffering from respiratory diseases.
The various districts of the other states are shown in Table 13.1.

Table 13.1. Districts under the study area as per 1991 census.

Haryana	Himachal Pradesh	Rajasthan	Uttar Pradesh
Ambala, Bhiwani, Faridabad, Gurgaon, Hissar, Jind, Kaithal, Karnal, Kurushetra, Mahendragarh, Panipat, Rewari, Rohatak, Sirsa, Sonepat, Yamunanagar.	Shimla, Sirmaur, Solan.	Alwar, Bharatpur, Churu, Dhaulpur, Ganganagar, Jaipur, Jhunjhunu, Sawai Madhopur, Sikar.	Agra, Aligarh, Bulandshahr, Dehradun, Etah, Etawah, Firozabad, Ghaziabad, Hardwar, Mainpuri, Mathura, Meerut, Muzaffarnagar, Saharanpur, Tehrigarhwal, Uttarkashi

CHAPTER 14

Study design

Exposure assessment component of this study is part of the broader objective to value the damage in economic term caused by air pollution on human health. The main independent variable from the environmental side was chosen to be the daily integrated exposure of each target population. This index has the advantage of taking into consideration the level of pollution as well as the time spent in the polluted environment. The daily integrated exposure was assessed by splitting the day into many parts called micro-environments. Level of pollutants for all possible micro-environments are not available in literatures. The gap in levels of pollutants in these micro-environments and the time spent in them was estimated independently to arrive at integrated exposure.

The assessment of daily exposure entailed measuring concentrations of pollutants in important micro-environments and obtaining information through a questionnaire based surveys on time spent by target population in these micro-environments. Literature identifies the optimum number of micro-environments (type and number vary depending upon age and sex) necessary for estimating daily exposure.

The daily integrated individual exposure is computed as follows:

$$E = \sum_{i=1}^{m} C_i t_i$$

where E = Integrated daily exposure of an individual

C_i = Concentration in the ith micro-environment

t_i = Time spent by an individual in the ith micro-environment

m = Number of micro-environments for an individual.

Here,

$$\sum_{i=1}^{m} t_i = 24 \text{ h}$$

for all i.

Also,

$$s_i \leq t_i$$

where s_i is the duration of sampling in the ith micro-environment.

Micro-environments

Micro-environment is a definite time period in which the level of pollutants remains relatively constant. For instance, during office hours if a person is sitting in the office for eight hours then he will be exposed to same level of pollution but it would be different when he travel to his house on a scooter because then air will have higher concentration of pollutant because of exhaust of various vehicles. A field survey was conducted through questionnaire (Appendix 1) for generating information on time duration spent in various micro-environment (totaling to 24 hours and hence called time budget) so as to do exposure calculation. Various micro-environments taken up in this study are: cooking (indoor), resting in houses (indoor), sleeping (indoor), office/school (indoor), commuting (outdoor), walking (outdoor).

Air pollution monitoring

Concentration levels are available for some of the micro-environment in urban and rural areas but there are many gaps to it. To fill this gap monitoring was done for the following micro-environments in Delhi. It is expected that there would be large variation in the commuting air quality level because vehicles bring high level of concentration thus it is advisable to catch these variation. Selected micro-environments are shown in Table 14.1.

Table 14.1 Identified micro-environments with respect to time for air quality monitoring

Micro-environment	*Time*
Cooking Session	Since morning but before 10 am
Non-cooking session	After 10 am but before 12 am and after 2 but before 6 pm
Sleeping session	After 10 pm
Commuting duration (bus, auto, scooter and car)	After 8 am but before 10 am and after 5 pm but before 8 pm
Office (Central AC, Room AC, No AC)	After 10 am but before 6 pm
Schools	After 10 am but before 6 pm
Shops	After 10 am but before 6 pm

Due to the insufficient health data obtained from the Ministry of Health, Govt of Delhi, lead us for the field survey on health as well, through the use of the same questionnaire. The health survey was mainly conducted to assess the main problems caused by the air pollutants and the expenditure incurred by the family towards medical treatment.

CHAPTER 15

Results based on primary data

Time budget and health survey was conducted in 32 locations of Delhi through questionnaire. Six enumerators were trained on the various questions to be asked and how to put the responses in the questionnaire form. In first go, hundred questionnaires were surveyed by the six enumerators. The responses were studied and their problems encountered in field were analyzed closely with respect to the questionnaire and accordingly some changes were made in questionnaires. In the final go, 1000 houses were surveyed in the month of July-August, 1996.

The houses were chosen from 32 different localities (Table 15.1) spread in all over Delhi. A locality was further divided in three types of houses, i.e., high, middle, and low income area and for this housing type was used as criteria. Hence, approximately 10 questionnaire were filled in one housing type of a locality with random selection of houses keeping in mind that total houses shall be evenly spread in the area.

Table 15.1. Localities for questionnaire survey

Area	*Locality*		
Industrial	1. Khajuri Khas	2. Pandav Nagar	3. Okhla Tank
	4. Harikesh Nagar	5. Sico Industries	6. Vayu Bodhan Phase I
	7. BJW Industries	8. Okhla Phase - III	9. Kamal Plastics
	10. Najafgarh Road	11. Mayapuri	12. K Pharmaceutical
	13. Khajan Basti	14 Sakur Basti	
Commercial & Residential	1. CSIR Head office	2. Town Hall	3. Ram Nagar
	4. Maharani Bagh	5. Greater Kailash - II	6. Moti Bagh
	7. Sarvapriya Vihar	8. Govindpuri	9. Punjabi Ref Camp
	10. Netaji Nagar	11. Shiva Nagar	12. Janakpuri
	13. Lawrence Road	14. Prem Nagar	15. Pahadganj
	16 Patel Nagar		
Sensitive Area	1. Kailash Hills	2 Gautam Nagar	

Fuel usage

All 1100 questionnaires were analyzed. The study revealed the fact that there were 4288 persons in 1100 households which puts the family size on an average of four. The households were located broadly in three areas in the region. They are about 148 households in industrial (13.5%) area, 84 in commercial (7.6%), 809 residential and sensitive areas (73.5%) and about

59 in rural area (5.4%). The majority of families had income level below five thousand rupees (62.4%) and 31.4% were below ten thousand rupees monthly income and 5.4% were below twenty thousand family incomes. The monthly income of the family gives a broad idea about the socio economic status. This is one of the parameter which was considered while dividing the sample population. Out of the 1100 households, 46.5% (511) houses are adjacent to a road, 32.8% (361), 11.7% (129) were situated the either by a side of a waste disposal sites or by the side of drainage channel, and about 9% (99) of houses were located by the side of an industrial unit.

Table 15.2. Fuel use pattern in the sample area

Fuel	*Unit*	*Average*	*SD*	*Number of house*
LPG	Number	1.2	0.4	742
Kerosene	Litre	16.5	8 4	417
Wood	Kg	54 2	55.2	47
Dungcake	Kg	53.3	36.9	9
Coal	Kg	77 5	82.6	4
Charcoal	Kg	22.5	5	4

It can be seen from the Table 15.2 that in majority of households LPG (742 houses) is used while 417 houses were observed to use kerosene as a cooking fuel. The use of other cooking fuels like wood, dung cake, coal and charcoal were negligible.

Table 15.3. Space heating device use in the winter season

Space heating device	*Number of house*	*Percentage*
None	429	38.5
AC	40	3.6
Heater	481	43 7
Charcoal	32	2.9
Wood	116	10.5
Dungcake	8	0.7

Table 15.3 shows that in winter season there were various heating devices used for space heating purpose. About 43.7 % used heaters in winter season and 38.5% never used any space heating device. They were negligible number (14.1%) of user of charcoal, dungcake and wood. About 3.6% used air conditioners in their houses. The use of dungcakes, wood, and charcoal as space heating devices causes high levels indoor air pollution. The extent of indoor air pollution increases with the number of hours of burning. The study showed the duration of space heating varied from less than two hours to twenty four hours.

Time budget

Seven types of micro-environments were identified in the first stage of the questionnaire survey. However, from air quality point of view, times spent were grouped into six types of micro-environments. The time spent by various population groups is shown in Table 15.4.

Table 15.4. Time budget of different population groups (hours)

Group	*Kitchen*	*Commuting*	*Workplace*	*Indoor*	*Outdoor*	*Sleeping*
Infants	0.4	0.4	0	9.1	1.9	12.2
Male students	0	1.7	6	3.4	4.3	8.6
Female students	0.6	1.6	6	5.1	2.1	8.6
Male workers	0	2 1	8.5	2.8	2 8	7.8
Female workers	2.2	1.7	7.1	4.1	1	7.9
Male marginal workers	0	2.1	4	7 3	2.8	7.8
Female marginal workers	2.2	1.7	4	7.2	1	7.9
Housewives	4	0.7	0	8.9	1.9	8.5
Male elders	0	1.1	3	7.6	2.6	9.7
Female elders	0.3	0	0	11.1	3.3	9.3
Male unemployed	0	1.4	2 8	5.4	4.7	9.7
Female unemployed	4	0	0	9	1.9	9.1

Different time budgets were observed for different genders for various age groups. The working hours varied from 6 to 8 in case of males, and in case females it is 6 to 7 hours. Time taken for traveling in both the genders, either to school, college, office or the other work places were found to be the same. On an average the female have been found to spend two

hours of their time in kitchen. Most of the study population (both genders) get exposed to the air pollutants during their traveling and while cooking. The exposure to the pollutant also varies with the mode of conveyance incase of traveling and even emission of pollutants varies with the cooking fuel.One significant revelation of the survey is that most of people spend at least two hours for traveling, this is one mode of exposure to the polluted air.

Smoking profile

Of 1100 houses surveyed, 536 persons were found to have smoking habit in 481 houses. The details are shown in Table 15.5.

Table 15.5. Smoking profile of the surveyed population

Type of smoking	*Percent*	*Place of smoking*	*Percent*	*Average number of items smoked*
Cigarette	49 30	Inside of the house	11 00	11
Bidi	50 00	Outside of the house	5.80	9
Hookah	0.70	Both the places	83.20	13

Air quality

Field experiments were conducted in the month of January-April, 1997 to measure level of RSP and CO in different micro-environments. The summary result is presented in Table 15.6.

Table 15.6. Measured concentration of respirable suspended particulates (RSP) in $\mu g/m^3$ and carbon monoxide (CO) in ppm.

Micro-environments	*RSP*	*SD*	*n*	*CO*	*SD*	*n*
Cooking	891	463	9	6	1	9
Non-cooking	479	287	9	0	0	3
Sleeping	638	346	9	0	0	3
School	227	69	9	0	0	3
Office/shops	350	230	9	3	4	9
Commuting-auto	810	143	9	12	4	9
Commuting-bus	803	213	9	8	1	9
Commuting-car	373	71	9	10	2	9
Commuting-scooter	2858	1467	9	19	5	9

SD = standard deviation, n = sample size

It can be seen that concentration of RSP as well as CO was maximum during commuting duration by scooter/two wheeler mode while RSP was minimum in car and CO in bus. However, a summery information has been made which includes the finding of present study and literature values for additional requirements to compute exposure.

The findings of this study can be compared with the study done at two slums in Delhi (Saksena et al). The RSP and CO level are in the same order to the level of kerosene during cooking. Non cooking indoor concentrations are also in the same order. The level of RSP during commuting has been observed in the same order and magnitude of the study done by Akbar et al except in the bus mode where this study finds it double. This can be explained on the basis that the measurement were done during peak hours with all windows of the buses open in maximum cases.

Table 15.7. Typical concentration of RSP and CO in various micro-environments

	RSP (mg/m³)			*CO (ppm)*		
Micro-environment	*Urban*	*Rural*	*Slum*	*Urban*	*Rural*	*Slum*
Cooking-biomass	1.1	1.4	1 2	16	16	16
Cooking-coal	1.5	1.5	1.5	96	96	96
Cooking-kerosene	0.5	0.7	0.7	5	5	2
Cooking-LPG	0.9	0.7	0.7	6	6	3
Commuting	1 5	1.5	1.5	13	13	7 (6)
Workplace	0.35	0.3	0.3	3	3	0
Indoor	0.5	0.4	0 3	0	0	0
Outdoor	0.3	0.3	0 1	0	0	0
Sleeping	0.6	0.6	0.6	0	0	0
School	0.2	0.2	0.2	0	0	0

Sources 1 Present study; 2. Saksena S, Dayal V, 1997; 3. Riyani et al., 1993

All figures are for 1991 while figures in parentheses are the value for the year of 1981. The commuting and outdoor values were modified using emission weighted average of number of vehicles for the corresponding years while outdoor value was taken from literature.

Exposure

Daily integrated exposure was calculated as described in chapter 13. Time budget information and concentration of the pollutant in various micro-environments were used to compute daily integrated exposure. Table 15.8 presents the finding for all population groups.

Table 15.8. Daily integrated exposure of RSP (mg-day/m^3) and CO (ppm-day) for the year 1991

Category	*RSP*	CO
Rural infant	8	14
Urban infant	13	18
Slum infant	13	18
Rural student	8	25
Urban student	13	54
Slum student	13	54
Rural worker (male)	9	15
Urban worker (male)	13	44
Slum worker (male)	12	44
Rural worker (female)	10	73
Urban worker (female)	14	104
Slum worker (female)	14	104
Rural marginal worker	10	61
Urban marginal worker	11	66
Slum marginal worker	14	89
Rural housewives	11	116
Urban housewives	15	132
Slum housewives	15	132
Rural elders	7	8
Urban elders	13	12
Slum elders	12	12
Rural unemployed	9	91
Urban unemployed	14	104
Slum unemployed	14	104

Table 15.8 indicates that urban, slum housewives are among the highest risk of exposure followed by female urban and slum worker, slum marginal worker while rural old people are lest exposed to RSP. Urban and slum housewives are maximum exposed to carbon monoxide.

Population exposure

The entire population of Delhi was divided in twenty four sub-groups based on their characteristics of activities they carry in a day. This involved consideration of rural, urban and slum population, male and female population, 8 activity based populations, i.e. workers,

marginal workers, housewives, unemployed males, infants (0-5 years), school & college children and elderly (>65 years). The cooking environment was further subdivided into Cow-dung, charcoal, and wood; coal, coke, and lignite; kerosene; LPG & biogas.

Table 15.9. Population exposure for RSP (person-mg-day/m^3) and CO (person-ppm-day) and burden in percentage

Category	*RSP*	*CO*	*RSP burden*	*CO burden*
Rural infant	974536	671930	0.8	0.2
Urban infant	7477825	4509181	6 3	1.3
Slum infant	4923481	3185667	4 2	0.9
Rural student	2443917	4301817	2.1	1.2
Urban student	21049416	68247137	17.9	19.7
Slum student	14105216	48215554	12.0	14.0
Rural worker (male)	2195473	3709192	1.9	1.1
Urban worker (male)	18357485	71221815	15.6	20.6
Slum worker (male)	12305169	50317119	10.4	14.6
Rural worker (female)	204113	515730	0.2	0.1
Urban worker (female)	2312412	9670898	2.0	2.8
Slum worker (female)	1547262	6832341	1.3	2.0
Rural marginal worker	32686	79136	0.0	0.0
Urban marginal worker	59988	152542	0 1	0.0
Slum marginal worker	46237	156737	0 0	0.0
Rural housewives	1585744	4537259	1 3	1.3
Urban housewives	11739781	31084500	10 0	9.0
Slum housewives	7786231	21960722	6 6	6 4
Rural elders	256747	176860	0.2	0.1
Urban elders	2159877	2222551	1.8	0.6
Slum elders	1407781	1570198	1.2	0 5
Rural unemployed	418133	1016170	0.4	0.3
Urban unemployed	2666854	6576962	2.3	1.9
Slum unemployed	1816368	4646522	1 5	1.3

Table 15.9 gives details of population exposure for various population groups and distribution of burden in percentage for the groups.

Health status

The health questionnaire survey was conducted among 7680 respondents, out of which 64.6% of the sample population responded that they are healthy without any minor ailment. About 8.3%, 8.1%, 6.2%, 4.6%, 3.3% and 3% suffer from cough, fever, breathing problems, nasal discharge, eye irritation and sore throat respectively. The other ailments like skin itching and ear discharge were very negligible. There were about 6.3% population responded saying that they suffer from the chronic diseases. About 93.7% of the sampled population responded as they were quite healthy with out any problem.

The study also revealed that percentage of incidence of the ailments increased from 3.2% (1990) to 7.4% (1996).

About 418 of the respondents consult either an allopathic doctor or hospital/nursing homes/ dispensary and about 46 of the respondent consulted quacks. Approximately four days of leave was taken in the case of minor ailments. The medical expenditure data was collected from all the respondents who suffered from minor ailments it ranged from Rs. 24/ only (in the area Premnagar) to Rs.175/ only (in the area Greater Kailash II). The Table 15.10 gives the medical expenditure towards minor ailments. About 1483 responded that they spend an amount between Rs. 25 to 50/ only.

Table 15.10. Expenditure towards the treatment of ailments

Expenditure (range in Rupees)	*Respondents*	*Area*
0 - 25	147	Prem Nagar
26 - 50	1483	Seelampur, Mayapuri, Gazipur, Paharhanj, Patel Nagar, Okhla dump site, Town hall, Sarvapriya Vihar, Khajuri Khas, Okhla tank, Netaji Nagar, Govindpuri
51 - 75	372	Khajan Basti, Nangloi, Okhla Ph III, Najafgarh Road, Gautam Nagar, Ashok Vihar
76 - 100	150	CSIR head office, Panjabi bagh refugee Camp, Harikesh Nagar
101 - 125	90	Bhalsawa dump site, Moti Bagh
126 - 150	230	Pandav Nagar, Shakur Basti, Lawrence Road, Janakpuri dumpsite
151 - 175	38	Greater Kailash II

Table 15.11 gives a rough estimate of the medical expenditure incurred by the population in the respective area. The expenditure for the entire family for the treatment of major diseases ranged between Rs. 100/only (in the area Najafgargh Road) to Rs. 3400/ only (in the

area Govidpuri). The majority (417) of the population responded that they spend less than Rs. 500/ only. In eleven areas the house hold's medical expenditure was over one thousand rupees and in remaining areas it was less than one thousand rupees.
An average 13 days leave was taken by the population, who suffered from a major disease.

Table 15.11. Expenditure towards the treatment of major diseases

Expenditure (range in Rupees)	*Respondents*	*Area*
0 - 500	417	Mayapuri, Khajan Basti, Okhla dumpsite, Okhla Ph III, Najafgarh Road, CSIR Head Office, Kailash hills, Govindpuri, Okhla tank, Harikesh Nagar
501 - 1000	153	Gazipur, Lawrence Road, Nangloi, Town hall, Ram Nagar, Maharanibagh, Greater Kailash II, Netaji Nagar, Ashok Vihar
1001 - 1500	79	Paharganj, Bhalsawa dumpsite, Motibagh, Panjabi refugee camp, Khajuri Khas
71501 - 2000	47	Seelampur, Janakpuri, Sarvapriya Vihar, Pandav Nagar
2501 - 3500	18	Sakur basti, Govindpuri, Patel Nagar

The incidence of minor ailments was found to be 4.8 % in winter season, 10.2 % and 11.5% in summer and rainy seasons respectively. The present study reveals the fact that the human exposure to the air pollutants are quite high and it may lead to various respiratory diseases in the long run, even though large number of people responded, that they are quite healthy.

CHAPTER 16

Results based on secondary information

Exposure account

Though time budget and air quality will vary district-wise and location-wise in the study area of Yamuna river sub-basin, however these information i.e., time budget and air quality information as used in the previous chapter was made the basis to arrive district-wise exposure account for respirable suspended particulate (RSP) and carbon monoxide (CO).

Total population was divided into 24 sub-groups as explained earlier. Daily integrated exposure was computed by multiplying concentration in the micro-environment and time spent into that. Average daily exposure was then calculated for various population sub-groups. The daily integrated exposure was further multiplied with the population of the sub-group. Exposure accounts is computed in person-mg-day/m^3 for RSP and person-ppm-day for CO.

District-wise exposure account is shown in the Table 16.1 to Table 16.44.

Health status

Rajasthan

Communicable diseases like tuberculosis, malaria, leprosy, guinea worm are major problem in Rajasthan. The number of new cases of tuberculosis reported in 1992 was 36,535. The present prevalence rate of tuberculosis in Rajasthan is 16 per 1000 population. Despite battling against tuberculosis for the last four decades it still continues to be a major public health problem in Rajasthan. In 1992 the number of sputum tests done was 74535. The number of new cases detected was 6535. The average annual rate of growth of tuberculosis cases during 1985 -86 to 1992-93 was 9.97%. The average annual rate of growth of tuberculosis patient was 9.97%. According to the survey of causes death the highest percentage of deaths in Rajasthan in 1990 were caused by cough related diseases such as asthma, bronchitis, tuberculosis, pneumonia, whooping cough etc.

For the state of Rajasthan, health data was collected for the districts, which fall under the Yamuna sub basin. There was sufficient secondary data available from the secondary sources like State Bureau of Health Intelligence.

Uttar Pradesh

The survey conducted by the Register General Office showed an overview of the prevailing disease pattern and causes of deaths in the state. The most useful information provided by this survey relates to distribution of deaths according to major cause groups of deaths. Individually, they comprise a number of specific disease which have symptoms association that are usually observed during the advanced stage of disease. Communicable diseases constitute major cause of ill health in the state be it through contribution to morbidity, disability or mortality. According to ICMR , a major share in this attributable to nine diseases

viz. Tuberculosis, tetanus, diarrhea, acute respiratory infection, measles, malaria, poliomyelitis, leprosy and filariasis. Major cause group " coughs" (disorders of respiratory system) is maintaining its second position 23.9 in 1990 and gone up to 24.1 in 1992. Bronchitis and asthma 32.7%, pneumonia 38.9% and TB of lungs 26.4% are the prominent diseases in the major cause group "cough". Malnutrition is clearly visible in a significant population of the state. It is more prevalent in the eastern districts of UP than in the western and other parts. Infants, preschool children and pregnant and lactating mothers, certain socio economic groups are more vulnerable than others to the ills of malnutrition. The problem of malnutrition, particularly among children are several in urban slums as in rural or tribal areas. Review of studies on urban slum dwellers reveals that their energy intake is far below the city average while they have a higher mortality rate and incidence of infectious diseases. With increasing rural urban migration, the problem will only intensify unless special efforts are made to check them.

Health accounts district-wise for various years has also been shown in Table 16.45 to Table 16.72.

Table 16.1 Exposure (person-day-mg/cubic meter) for Ambala district (Haryana)

Category	*RSP*	*CO*
Rural infant	849,588	726,236
Urban infant	466,126	304,745
Slum infant	108,483	76,186
Rural student	1,873,449	3,502,794
Urban student	1,431,936	4,772,596
Slum student	340,370	1,193,149
Rural worker (male)	1,628,394	2,955,817
Urban worker (male)	1,036,148	4,000,517
Slum worker (male)	245,855	1,000,129
Rural worker (female)	76,454	239,566
Urban worker (female)	132,565	581,643
Slum worker (female)	31,196	145,411
Rural marginal worker	27,414	84,848
Urban marginal worker	4,754	11,448
Slum marginal worker	1,525	5,920
Rural housewives	1,140,175	4,360,735
Urban housewives	704,867	2,143,835
Slum housewives	163,748	535,959
Rural elders	193,044	149,515
Urban elders	177,260	183,666
Slum elders	40,925	45,916
Rural unemployed	278,280	744,114
Urban unemployed	183,140	556,876
Slum unemployed	44,818	139,219

Table 16 2 Exposure (person-day-mg/cubic meter) for Kurushetra district (Haryana)

Category	*RSP*	*CO*
Rural infant	576,573	501,855
Urban infant	181,192	122,876
Slum infant	42,262	30,719
Rural student	1,271,339	2,392,311
Urban student	556,108	1,854,906
Slum student	132,230	463,726
Rural worker (male)	1,041,177	1,950,822
Urban worker (male)	401,627	1,477,134
Slum worker (male)	95,608	369,283
Rural worker (female)	49,851	165,516
Urban worker (female)	36,524	162,049
Slum worker (female)	8,703	40,512
Rural marginal worker	46,681	148,182
Urban marginal worker	764	1,965
Slum marginal worker	225	848
Rural housewives	751,291	2,930,098
Urban housewives	270,888	880,916
Slum housewives	64,188	220,229
Rural elders	130,775	101,621
Urban elders	68,660	73,032
Slum elders	15,859	18,258
Rural unemployed	197,759	533,540
Urban unemployed	76,780	238,728
Slum unemployed	18,835	59,682

Table 16.3 Exposure (person-day-mg/cubic meter) for Karnal district (Haryana)

Category	RSP	CO
Rural infant	759,594	664,697
Urban infant	285,974	194,629
Slum infant	66,699	48,657
Rural student	1,673,752	3,148,802
Urban student	877,927	2,932,219
Slum student	208,756	733,055
Rural worker (male)	1,357,888	2,539,396
Urban worker (male)	654,830	2,429,251
Slum worker (male)	155,795	607,313
Rural worker (female)	116,507	396,191
Urban worker (female)	65,418	291,629
Slum worker (female)	15,582	72,907
Rural marginal worker	44,835	142,794
Urban marginal worker	6,836	17,686
Slum marginal worker	2,016	7,575
Rural housewives	995,297	3,910,076
Urban housewives	430,068	1,406,056
Slum housewives	101,872	351,514
Rural elders	172,475	135,106
Urban elders	108,486	114,671
Slum elders	25,056	28,668
Rural unemployed	232,611	626,439
Urban unemployed	108,726	337,643
Slum unemployed	26,660	84,411

Table 16.4 Exposure (person-day-mg/cubic meter) for Jind district (Haryana

Category	RSP	CO
Rural infant	942,296	848,585
Urban infant	195,802	168,324
Slum infant	46,076	42,081
Rural student	2,075,642	3,935,189
Urban student	597,227	1,996,968
Slum student	141,959	499,242
Rural worker (male)	1,662,532	3,142,081
Urban worker (male)	424,814	1,529,436
Slum worker (male)	101,267	382,359
Rural worker (female)	229,136	817,717
Urban worker (female)	31,956	162,964
Slum worker (female)	7,970	40,741
Rural marginal worker	303,933	1,012,235
Urban marginal worker	6,187	18,929
Slum marginal worker	2,010	9,223
Rural housewives	1,125,388	4,634,487
Urban housewives	306,604	1,438,225
Slum housewives	78,100	359,556
Rural elders	214,275	170,604
Urban elders	73,709	79,059
Slum elders	17,023	19,765
Rural unemployed	109,771	307,629
Urban unemployed	27,667	86,811
Slum unemployed	6,767	21,703

Table 16.5 Exposure (person-day-mg/cubic meter) for Sonepat district (Haryana)

Category	*RSP*	*CO*
Rural infant	681,807	593,986
Urban infant	209,531	148,631
Slum infant	48,900	37,158
Rural student	1,501,540	2,815,867
Urban student	642,311	2,142,943
Slum student	152,722	535,736
Rural worker (male)	1,187,572	2,139,026
Urban worker (male)	458,386	1,722,485
Slum worker (male)	108,965	430,621
Rural worker (female)	200,937	679,324
Urban worker (female)	49,432	227,715
Slum worker (female)	11,804	56,929
Rural marginal worker	106,263	338,557
Urban marginal worker	2,658	7,077
Slum marginal worker	805	3,143
Rural housewives	794,549	3,104,692
Urban housewives	320,076	1,121,082
Slum housewives	76,208	280,270
Rural elders	155,021	121,922
Urban elders	79,325	84,186
Slum elders	18,322	21,047
Rural unemployed	228,286	609,114
Urban unemployed	86,705	266,826
Slum unemployed	21,244	66,706

Table 16.6 Exposure (person-day-mg/cubic meter) for Panipat district (Haryana)

Category	*RSP*	*CO*
Rural infant	717,814	629,205
Urban infant	266,008	186,339
Slum infant	62,077	46,585
Rural student	1,581,374	2,974,862
Urban student	816,676	2,726,636
Slum student	194,202	681,659
Rural worker (male)	1,264,726	2,352,059
Urban worker (male)	645,863	2,482,750
Slum worker (male)	153,295	620,688
Rural worker (female)	129,925	441,039
Urban worker (female)	58,204	268,744
Slum worker (female)	13,891	67,186
Rural marginal worker	111,855	360,216
Urban marginal worker	4,760	12,573
Slum marginal worker	1,463	5,769
Rural housewives	952,579	3,751,693
Urban housewives	405,523	1,403,316
Slum housewives	96,537	350,829
Rural elders	163,047	128,037
Urban elders	100,847	107,288
Slum elders	23,294	26,822
Rural unemployed	151,638	408,389
Urban unemployed	69,822	216,812
Slum unemployed	17,125	54,203

Table 16.7 Exposure (person-day-mg/cubic meter) for Rohtak district (Haryana)

Category	*RSP*	*CO*
Rural infant	1,683,804	1,490,708
Urban infant	453,855	321,726
Slum infant	105,900	80,432
Rural student	3,708,138	6,993,351
Urban student	1,391,280	4,653,493
Slum student	330,905	1,163,373
Rural worker (male)	2,866,386	5,276,242
Urban worker (male)	986,444	3,628,410
Slum worker (male)	234,823	907,103
Rural worker (female)	646,967	2,243,789
Urban worker (female)	104,845	472,542
Slum worker (female)	25,053	118,136
Rural marginal worker	377,854	1,212,828
Urban marginal worker	5,253	14,019
Slum marginal worker	1,554	5,968
Rural housewives	1,761,478	7,014,876
Urban housewives	659,059	2,298,065
Slum housewives	156,667	574,516
Rural elders	382,364	301,788
Urban elders	171,858	182,701
Slum elders	39,700	45,675
Rural unemployed	510,709	1,379,068
Urban unemployed	173,380	543,134
Slum unemployed	42,566	135,784

Table 16.8 Exposure (person-day-mg/cubic meter) for Faridabad district (Haryana)

Category	*RSP*	*CO*
Rural infant	898,932	706,753
Urban infant	843,124	99,777
Slum infant	197,028	23,362
Rural student	1,979,549	1,558,827
Urban student	2,588,573	305,557
Slum student	615,668	72,686
Rural worker (male)	1,485,932	1,100,544
Urban worker (male)	2,072,839	210,575
Slum worker (male)	492,245	50,081
Rural worker (female)	222,086	132,796
Urban worker (female)	162,708	13,345
Slum worker (female)	39,167	3,242
Rural marginal worker	231,794	384,780
Urban marginal worker	9,036	7,197
Slum marginal worker	2,805	2,322
Rural housewives	954,137	845,502
Urban housewives	1,617,770	146,675
Slum housewives	389,981	35,909
Rural elders	204,142	159,977
Urban elders	318,768	37,777
Slum elders	73,660	8,727
Rural unemployed	186,340	160,874
Urban unemployed	220,829	28,633
Slum unemployed	54,232	7,045

Table 16.9 Exposure (person-day-mg/cubic meter) for Gurgaon district (Haryana)

Category	*RSP*	*CO*
Rural infant	1,079,885	952,773
Urban infant	273,813	192,166
Slum infant	63,859	48,042
Rural student	2,380,056	4,492,719
Urban student	839,740	2,807,064
Slum student	199,685	701,766
Rural worker (male)	1,805,863	3,309,367
Urban worker (male)	603,376	2,286,147
Slum worker (male)	143,351	571,537
Rural worker (female)	274,491	950,686
Urban worker (female)	74,706	338,975
Slum worker (female)	17,790	84,744
Rural marginal worker	492,871	1,608,526
Urban marginal worker	5,189	13,582
Slum marginal worker	1,603	6,342
Rural housewives	1,175,394	4,673,897
Urban housewives	404,896	1,391,709
Slum housewives	95,840	347,927
Rural elders	245,071	192,159
Urban elders	103,765	109,881
Slum elders	23,967	27,470
Rural unemployed	241,192	658,080
Urban unemployed	75,787	237,269
Slum unemployed	18,592	59,317

Table 16.10 Exposure (person-day-mg/cubic meter) for Mahendragarh district (Haryana)

Category	*RSP*	*CO*
Rural infant	706,753	626,564
Urban infant	99,777	75,201
Slum infant	23,362	18,800
Rural student	1,558,827	2,955,347
Urban student	305,557	1,023,202
Slum student	72,686	255,801
Rural worker (male)	1,100,544	2,021,867
Urban worker (male)	210,575	785,612
Slum worker (male)	50,081	196,403
Rural worker (female)	132,796	460,318
Urban worker (female)	13,345	63,333
Slum worker (female)	3,242	15,833
Rural marginal worker	384,780	1,250,556
Urban marginal worker	7,197	19,319
Slum marginal worker	2,322	9,766
Rural housewives	845,502	3,368,449
Urban housewives	146,675	564,463
Slum housewives	35,909	141,116
Rural elders	159,977	124,509
Urban elders	37,777	39,890
Slum elders	8,727	9,973
Rural unemployed	160,874	441,226
Urban unemployed	28,633	91,173
Slum unemployed	7,045	22,793

Table 16.11 Exposure (person-day-mg/cubic meter) for Bhiwani district (Haryana)

Category	*RSP*	*CO*
Rural infant	1,116,031	987,806
Urban infant	231,550	174,118
Slum infant	54,178	43,529
Rural student	2,459,862	4,651,263
Urban student	709,455	2,372,741
Slum student	168,754	593,185
Rural worker (male)	1,756,029	3,290,066
Urban worker (male)	496,486	1,790,196
Slum worker (male)	118,341	447,549
Rural worker (female)	410,013	1,431,654
Urban worker (female)	37,772	174,538
Slum worker (female)	9,169	43,634
Rural marginal worker	521,657	1,685,343
Urban marginal worker	7,358	20,226
Slum marginal worker	2,367	9,958
Rural housewives	1,140,797	4,536,986
Urban housewives	363,234	1,402,714
Slum housewives	88,430	350,679
Rural elders	252,977	198,035
Urban elders	87,611	93,375
Slum elders	20,240	23,344
Rural unemployed	250,807	682,309
Urban unemployed	65,625	207,380
Slum unemployed	16,134	51,845

Table 16.12 Exposure (person-day-mg/cubic meter) for Hisar district (Haryana)

Category	*RSP*	*CO*
Rural infant	1,716,549	624,555
Urban infant	460,685	112,109
Slum infant	108,395	26,213
Rural student	3,785,293	1,378,647
Urban student	1,404,879	343,508
Slum student	333,794	81,696
Rural worker (male)	1,454,544	897,040
Urban worker (male)	1,060,578	254,789
Slum worker (male)	252,758	60,481
Rural worker (female)	615,358	117,519
Urban worker (female)	97,649	16,245
Slum worker (female)	24,345	3,917
Rural marginal worker	353,687	227,102
Urban marginal worker	12,526	6,162
Slum marginal worker	4,104	1,956
Rural housewives	1,784,633	823,419
Urban housewives	733,238	162,489
Slum housewives	186,618	39,322
Rural elders	390,222	141,254
Urban elders	173,461	42,394
Slum elders	40,048	9,794
Rural unemployed	1,892,175	248,474
Urban unemployed	600,831	55,228
Slum unemployed	146,648	13,582

Table 16.13 Exposure (person-day-mg/cubic meter) for Sirsa district (Haryana)

Category	*RSP*	*CO*
Rural infant	840,387	715,190
Urban infant	226,071	193,471
Slum infant	53,190	48,368
Rural student	1,854,254	3,467,464
Urban student	689,524	2,292,817
Slum student	163,856	573,204
Rural worker (male)	1,538,302	2,941,691
Urban worker (male)	533,531	1,985,528
Slum worker (male)	126,909	496,382
Rural worker (female)	229,053	768,693
Urban worker (female)	36,244	190,784
Slum worker (female)	9,003	47,696
Rural marginal worker	326,425	1,027,986
Urban marginal worker	1,549	4,560
Slum marginal worker	423	1,633
Rural housewives	960,075	3,652,795
Urban housewives	366,614	1,708,658
Slum housewives	93,265	427,165
Rural elders	190,805	146,790
Urban elders	85,186	89,664
Slum elders	19,668	22,416

Table 16.14 Exposure (person-day-mg/cubic meter) for Riwari district (Haryana)

Category	*RSP*	*CO*
Rural infant	624,555	563,541
Urban infant	112,109	89,526
Slum infant	26,213	22,381
Rural student	1,378,647	2,635,087
Urban student	343,508	1,149,978
Slum student	81,696	287,494
Rural worker (male)	897,040	1,645,283
Urban worker (male)	254,789	977,789
Slum worker (male)	60,481	244,447
Rural worker (female)	117,519	414,738
Urban worker (female)	16,245	82,110
Slum worker (female)	3,917	20,527
Rural marginal worker	227,102	746,045
Urban marginal worker	6,162	19,031
Slum marginal worker	1,956	8,654
Rural housewives	823,419	3,379,465
Urban housewives	162,489	697,573
Slum housewives	39,322	174,393
Rural elders	141,254	110,124
Urban elders	42,394	45,563
Slum elders	9,794	11,391

Table 16.15 Exposure (person-day-mg/cubic meter) for Kaithal district (Haryana)

Category	*RSP*	CO
Rural infant	828,300	738,133
Urban infant	142,050	111,331
Slum infant	33,265	27,833
Rural student	1,824,313	3,449,039
Urban student	435,393	1,457,170
Slum student	103,559	364,292
Rural worker (male)	1,457,631	2,763,850
Urban worker (male)	324,368	1,146,828
Slum worker (male)	77,411	286,707
Rural worker (female)	110,706	385,202
Urban worker (female)	20,814	101,862
Slum worker (female)	5,065	25,465
Rural marginal worker	194,417	635,907
Urban marginal worker	4,455	13,082
Slum marginal worker	1,442	6,288
Rural housewives	1,136,321	4,569,391
Urban housewives	216,975	901,718
Slum housewives	53,208	225,430
Rural elders	188,046	148,644
Urban elders	53,777	57,294
Slum elders	12,423	14,323
Rural unemployed	101,216	276,020
Urban unemployed	21,846	68,827
Slum unemployed	5,365	17,207

Table 16.16 Exposure (person-day-mg/cubic meter) for Yamunanagar district (Haryana)

Category	*RSP*	CO
Rural infant	644,054	563,781
Urban infant	325,423	222,251
Slum infant	75,996	55,563
Rural student	1,420,243	2,677,905
Urban student	999,164	3,335,912
Slum student	237,576	833,978
Rural worker (male)	1,096,668	2,059,323
Urban worker (male)	589,724	2,193,983
Slum worker (male)	140,279	548,496
Rural worker (female)	89,103	277,201
Urban worker (female)	127,750	587,346
Slum worker (female)	30,562	146,836
Rural marginal worker	23,626	73,110
Urban marginal worker	696	1,871
Slum marginal worker	188	660
Rural housewives	834,916	3,286,232
Urban housewives	466,236	1,538,753
Slum housewives	111,697	384,688
Rural elders	146,076	113,719
Urban elders	123,433	130,787
Slum elders	28,509	32,697
Rural unemployed	349,937	952,949
Urban unemployed	217,752	679,610
Slum unemployed	53,415	169,903

Table 16.17 Exposure (person-day-mg/cubic meter) for Shimla district (Himachal P

Category	RSP	CO
Rural infant	483,049	410,582
Urban infant	128,261	75,997
Slum infant	30,055	19,106
Rural student	1,279,547	2,389,357
Urban student	399,237	1,324,359
Slum student	95,451	332,954
Rural worker (male)	1,043,286	1,969,124
Urban worker (male)	1,261,744	3,419,070
Slum worker (male)	307,243	859,581
Rural worker (female)	784,022	2,650,741
Urban worker (female)	885,571	2,544,368
Slum worker (female)	215,763	639,674
Rural marginal worker	308,819	948,085
Urban marginal worker	25,953	55,024
Slum marginal worker	8,295	29,900
Rural housewives	103,908	393,396
Rural elders	179,040	138,107
Urban elders	45,991	55,624
Slum elders	10,698	13,984

Table 16.18 Exposure (person-day-mg/cubic meter) for Sirmaur district (Himachal Pradesh)

Category	RSP	CO
Rural infant	336,634	289,754
Urban infant	38,809	24,134
Slum infant	9,104	6,068
Rural student	890,261	1,663,835
Urban student	121,168	404,935
Slum student	28,977	101,804
Rural worker (male)	767,156	1,452,948
Urban worker (male)	101,158	374,474
Slum worker (male)	24,206	94,146
Rural worker (female)	404,473	1,381,395
Urban worker (female)	15,904	67,109
Slum worker (female)	3,812	16,872
Rural marginal worker	243,042	750,514
Urban marginal worker	1,355	3,306
Slum marginal worker	391	1,376
Rural housewives	182,165	700,270
Urban housewives	77,216	215,726
Slum housewives	18,424	54,235
Rural elders	124,893	97,730
Urban elders	13,834	15,886
Slum elders	3,216	3,994

Table 16.19 Exposure (person-day-mg/cubic meter) for Solan district (Himachal Pra

Category	RSP	CO
Rural infant	329,207	274,753
Urban infant	48,117	28,681
Slum infant	11,275	7,211
Rural student	871,796	1,617,340
Urban student	150,087	498,537
Slum student	35,876	125,336
Rural worker (male)	734,479	1,343,198
Urban worker (male)	144,467	539,071
Slum worker (male)	34,551	135,527
Rural worker (female)	251,055	826,298
Urban worker (female)	24,198	97,625
Slum worker (female)	5,775	24,544
Rural marginal worker	375,409	1,142,862
Urban marginal worker	5,695	12,567
Slum marginal worker	1,756	6,268
Rural housewives	370,805	1,373,132
Urban housewives	106,399	274,489
Slum housewives	25,126	69,009
Rural elders	122,198	94,017
Urban elders	17,194	19,989
Slum elders	3,997	5,025

Table 16.20 Exposure (person-day-mg/cubic meter) for Alwar district (Rajasthan)

Category	RSP	CO
Rural infant	2,293,841	2,027,427
Urban infant	394,835	275,262
Slum infant	92,332	68,816
Rural student	5,357,355	10,130,275
Urban student	1,208,036	4,031,745
Slum student	287,337	1,007,936
Rural worker (male)	3,776,020	7,123,708
Urban worker (male)	867,185	3,278,434
Slum worker (male)	206,058	819,609
Rural worker (female)	1,181,112	4,131,076
Urban worker (female)	83,858	356,740
Slum worker (female)	20,350	89,185
Rural marginal worker	2,286,315	7,362,171
Urban marginal worker	23,143	57,478
Slum marginal worker	7,435	29,683
Rural housewives	1,966,043	7,805,404
Urban housewives	574,632	1,965,986
Slum housewives	139,312	491,497
Rural elders	472,845	346,888
Urban elders	120,908	128,144
Slum elders	27,931	32,036

Table 16.21 Exposure (person-day-mg/cubic meter) for Bharatpur district (Rajastha

Category	RSP	CO
Rural infant	1,545,523	1,369,963
Urban infant	396,912	314,292
Slum infant	93,010	78,573
Rural student	3,603,096	6,787,584
Urban student	1,210,217	4,044,814
Slum student	287,877	1,011,204
Rural worker (male)	2,561,925	4,882,238
Urban worker (male)	791,793	2,835,931
Slum worker (male)	188,809	708,983
Rural worker (female)	313,779	1,093,825
Urban worker (female)	76,749	348,206
Slum worker (female)	18,854	87,051
Rural marginal worker	1,240,953	4,065,795
Urban marginal worker	48,203	138,747
Slum marginal worker	15,585	68,153
Rural housewives	1,864,615	7,425,922
Urban housewives	556,675	2,320,766
Slum housewives	137,191	580,192
Rural elders	317,550	236,780
Urban elders	121,335	127,422
Slum elders	28,028	31,855

Table 16 22 Exposure (person-day-mg/cubic meter) for Jaipur district (Rajasthan)

Category	RSP	CO
Rural infant	3,314,787	2,944,869
Urban infant	2,299,560	1,602,544
Slum infant	537,611	400,636
Rural student	7,744,754	14,684,595
Urban student	7,041,883	23,553,717
Slum student	1,675,034	5,888,429
Rural worker (male)	5,390,685	10,123,596
Urban worker (male)	6,688,315	25,867,520
Slum worker (male)	1,586,801	6,466,880
Rural worker (female)	2,058,306	7,230,641
Urban worker (female)	537,252	2,335,879
Slum worker (female)	130,028	583,970
Rural marginal worker	1,873,551	6,108,805
Urban marginal worker	81,723	208,137
Slum marginal worker	25,551	100,781
Rural housewives	2,209,512	8,836,742
Urban housewives	3,188,951	10,955,940
Slum housewives	771,537	2,738,985
Rural elders	683,766	501,235
Urban elders	706,815	737,630
Slum elders	163,257	184,407

Table 16.23 Exposure (person-day-mg/cubic meter) for Sawai Madhopur district (R

Category	RSP	CO
Rural infant	1,941,378	1,727,700
Urban infant	360,415	297,713
Slum infant	84,508	74,428
Rural student	4,529,398	8,560,539
Urban student	1,098,844	3,675,240
Slum student	261,382	918,810
Rural worker (male)	3,271,199	6,237,181
Urban worker (male)	700,530	2,519,675
Slum worker (male)	167,002	629,919
Rural worker (female)	901,065	3,177,304
Urban worker (female)	75,934	360,137
Slum worker (female)	18,697	90,034
Rural marginal worker	1,594,383	5,216,473
Urban marginal worker	39,232	120,882
Slum marginal worker	12,768	57,970
Rural housewives	1,940,339	7,776,158
Urban housewives	501,001	2,237,944
Slum housewives	124,072	559,486
Rural elders	399,431	296,558
Urban elders	110,241	115,417
Slum elders	25,464	28,854

Table 16.24 Exposure (person-day-mg/cubic meter) for Sikar district (Rajasthan)

Category	RSP	CO
Rural infant	1,689,048	1,496,953
Urban infant	479,623	382,839
Slum infant	112,511	95,710
Rural student	3,951,100	7,509,836
Urban student	1,462,293	4,899,526
Slum student	347,859	1,224,881
Rural worker (male)	2,492,536	4,669,102
Urban worker (male)	860,955	2,981,750
Slum worker (male)	205,732	745,438
Rural worker (female)	559,141	1,955,609
Urban worker (female)	60,123	280,325
Slum worker (female)	14,819	70,081
Rural marginal worker	1,167,925	3,782,913
Urban marginal worker	51,073	146,235
Slum marginal worker	16,108	69,087
Rural housewives	1,761,998	7,015,987
Urban housewives	595,139	2,508,365
Slum housewives	147,942	627,091
Rural elders	349,166	252,917
Urban elders	147,243	150,782
Slum elders	34,004	37,695
Rural unemployed	446,865	1,236,950
Urban unemployed	149,192	478,663
Slum unemployed	36,742	119,666

Table 16.25 Exposure (person-day-mg/cubic meter) for Jhunjhunu district (Rajastha

Category	RSP	CO
Rural infant	1,459,143	1,289,678
Urban infant	402,169	315,992
Slum infant	94,304	78,998
Rural student	3,412,611	6,476,733
Urban student	1,226,339	4,102,195
Slum student	291,708	1,025,549
Rural worker (male)	13,380,294	26,146,523
Urban worker (male)	726,542	2,387,639
Slum worker (male)	174,157	596,910
Rural worker (female)	420,556	1,467,928
Urban worker (female)	47,649	220,965
Slum worker (female)	11,715	55,241
Rural marginal worker	1,382,331	4,426,023
Urban marginal worker	46,409	130,686
Slum marginal worker	14,765	63,001
Rural housewives	1,659,197	6,583,438
Urban housewives	524,063	2,156,133
Slum housewives	129,858	539,033
Rural elders	301,533	218,528
Urban elders	123,212	127,728
Slum elders	28,457	31,932

Table 16 26 Exposure (person-day-mg/cubic meter) for Dhaulpur district (Rajasthan)

Category	RSP	CO
Rural infant	720,990	641,063
Urban infant	159,476	129,806
Slum infant	37,418	32,451
Rural student	1,678,857	3,155,716
Urban student	485,960	1,623,674
Slum student	115,594	405,918
Rural worker (male)	1,277,567	2,464,808
Urban worker (male)	319,746	1,090,835
Slum worker (male)	76,476	272,709
Rural worker (female)	59,650	207,623
Urban worker (female)	13,291	64,642
Slum worker (female)	3,272	16,161
Rural marginal worker	157,120	508,579
Urban marginal worker	1,745	5,105
Slum marginal worker	521	2,157
Rural housewives	940,881	3,764,399
Urban housewives	222,491	967,102
Slum housewives	55,395	241,776
Rural elders	147,822	111,486
Urban elders	48,671	51,450
Slum elders	11,243	12,863
Rural unemployed	164,850	438,572
Urban unemployed	43,340	134,710
Slum unemployed	10,636	33,677

Table 16.27 Exposure (person-day-mg/cubic meter) for Churu district (Rajasthan)

Category	RSP	CO
Rural infant	1,273,466	1,129,146
Urban infant	552,078	447,621
Slum infant	129,588	111,905
Rural student	2,978,157	5,657,600
Urban student	1,683,123	5,640,352
Slum student	400,408	1,410,088
Rural worker (male)	2,716,864	5,267,231
Urban worker (male)	1,046,030	3,545,326
Slum worker (male)	250,285	886,332
Rural worker (female)	844,017	2,970,077
Urban worker (female)	73,501	331,448
Slum worker (female)	18,243	82,862
Rural marginal worker	1,286,155	4,175,540
Urban marginal worker	45,997	134,034
Slum marginal worker	14,517	62,860
Rural housewives	862,795	3,436,658
Urban housewives	724,724	3,133,547
Slum housewives	181,076	783,387
Rural elders	263,129	191,050
Urban elders	169,495	173,509
Slum elders	39,143	43,377

Table 16.28 Exposure (person-day-mg/cubic meter) for Ganganagar district (Rajastha

Category	RSP	CO
Rural infant	2,403,932	2,129,824
Urban infant	681,836	528,159
Slum infant	159,833	132,040
Rural student	5,613,373	10,618,103
Urban student	2,082,789	6,960,186
Slum student	495,432	1,740,046
Rural worker (male)	4,467,709	8,524,368
Urban worker (male)	1,512,949	5,501,852
Slum worker (male)	360,424	1,375,463
Rural worker (female)	549,610	1,919,134
Urban worker (female)	89,079	429,654
Slum worker (female)	21,795	107,413
Rural marginal worker	1,861,167	6,082,238
Urban marginal worker	22,449	63,526
Slum marginal worker	6,964	29,045
Rural housewives	3,037,744	12,091,040
Urban housewives	1,049,838	4,273,597
Slum housewives	259,696	1,068,399
Rural elders	495,361	364,283
Urban elders	208,794	219,386
Slum elders	48,231	54,847

Table 16.29 Exposure (person-day-mg/cubic meter) for Agra district (Uttar Pradesh)

Category	RSP	CO
Rural infant	1,916,059	641,063
Urban infant	1,512,189	129,806
Slum infant	353,796	32,451
Rural student	4,373,466	3,155,716
Urban student	4,435,404	1,623,674
Slum student	1,055,068	405,918
Rural worker (male)	3,453,156	2,464,808
Urban worker (male)	2,973,604	1,090,835
Slum worker (male)	705,330	272,709
Rural worker (female)	142,742	207,623
Urban worker (female)	166,133	64,642
Slum worker (female)	40,155	16,161
Rural marginal worker	150,730	508,579
Urban marginal worker	39,940	5,105
Slum marginal worker	12,392	2,157
Rural housewives	2,671,055	3,764,399
Urban housewives	1,956,459	967,102
Slum housewives	475,688	241,776
Rural elders	469,689	111,486
Urban elders	385,668	51,450
Slum elders	89,159	12,863
Rural unemployed	435,557	438,572
Urban unemployed	373,273	134,710
Slum unemployed	91,667	33,677

Table 16 30 Exposure (person-day-mg/cubic meter) for Aligarh district (Uttar Pradesh

Category	RSP	CO
Rural infant	2,882,810	2,570,475
Urban infant	1,127,998	999,032
Slum infant	264,299	249,758
Rural student	6,582,290	12,409,997
Urban student	3,307,596	11,070,380
Slum student	786,793	2,767,595
Rural worker (male)	5,092,463	9,644,670
Urban worker (male)	2,084,327	7,804,969
Slum worker (male)	495,589	1,951,242
Rural worker (female)	332,733	1,148,698
Urban worker (female)	136,434	744,272
Slum worker (female)	33,220	186,068
Rural marginal worker	795,314	2,577,706
Urban marginal worker	50,793	175,267
Slum marginal worker	16,214	76,971
Rural housewives	4,078,896	16,387,124
Urban housewives	1,306,971	6,498,327
Slum housewives	321,696	1,624,582
Rural elders	706,868	539,430
Urban elders	287,586	324,786
Slum elders	66,481	81,197
Rural unemployed	296,250	802,061
Urban unemployed	125,611	395,333
Slum unemployed	30,858	98,833

Table 16.31 Exposure (person-day-mg/cubic meter) for Bulandshahr district (Uttar

Category	RSP	CO
Rural infant	2,636,879	2,374,582
Urban infant	807,230	701,639
Slum infant	189,211	175,410
Rural student	6,022,322	11,403,666
Urban student	2,366,842	7,933,218
Slum student	563,007	1,983,304
Rural worker (male)	4,497,244	8,491,161
Urban worker (male)	1,498,068	5,343,573
Slum worker (male)	357,320	1,335,893
Rural worker (female)	284,402	994,777
Urban worker (female)	79,929	410,247
Slum worker (female)	19,581	102,562
Rural marginal worker	627,950	2,050,999
Urban marginal worker	44,601	147,444
Slum marginal worker	14,078	64,897
Rural housewives	3,669,604	14,964,728
Urban housewives	998,612	4,815,787
Slum housewives	246,545	1,203,947
Rural elders	646,704	494,035
Urban elders	205,776	231,716
Slum elders	47,566	57,929
Rural unemployed	450.646	1,242,375

Table 16.32 Exposure (person-day-mg/cubic meter) for Dehradun district (Uttar Prad

Category	RSP	CO
Rural infant	591,845	467,833
Urban infant	696,988	430,569
Slum infant	162,365	107,642
Rural student	1,355,038	2,473,549
Urban student	2,053,206	6,754,655
Slum student	487,373	1,688,664
Rural worker (male)	1,155,371	2,082,681
Urban worker (male)	1,456,931	5,557,299
Slum worker (male)	345,984	1,389,325
Rural worker (female)	345,971	1,076,703
Urban worker (female)	158,491	667,843
Slum worker (female)	37,498	166,961
Rural marginal worker	199,257	565,276
Urban marginal worker	10,971	26,291
Slum marginal worker	3,201	11,393
Rural housewives	530,769	1,834,562
Urban housewives	948,020	2,606,404
Slum housewives	222,147	651,601
Rural elders	145,794	104,656
Urban elders	178,725	199,504
Slum elders	41,274	49,876

Table 16.33 Exposure (person-day-mg/cubic meter) for Etawah district (Uttar Prade

Category	RSP	CO
Rural infant	2,092,269	1,854,200
Urban infant	454,307	369,054
Slum infant	106,611	92,264
Rural student	4,776,561	8,981,436
Urban student	1,332,219	4,456,571
Slum student	316,898	1,114,143
Rural worker (male)	3,720,887	7,129,941
Urban worker (male)	836,179	3,029,700
Slum worker (male)	199,247	757,425
Rural worker (female)	111,020	379,543
Urban worker (female)	46,084	231,361
Slum worker (female)	11,318	57,840
Rural marginal worker	16,077	51,589
Urban marginal worker	2,601	7,585
Slum marginal worker	781	3,238
Rural housewives	3,146,096	12,528,549
Urban housewives	566,891	2,455,202
Slum housewives	141,323	613,800
Rural elders	512,979	391,315
Urban elders	115,832	130,530
Slum elders	26,777	32,633
Rural unemployed	427,178	1,144,802
Urban unemployed	100,515	314,320
Slum unemployed	24,686	78,580

Table 16 34. Exposure (person-day-mg/cubic meter) for Ghaziabad district (Uttar Pradesh

Category	RSP	CO
Rural infant	1,699,171	1,485,137
Urban infant	1,694,344	1,377,428
Slum infant	395,931	344,357
Rural student	3,880,729	7,272,180
Urban student	4,980,537	16,604,853
Slum student	1,184,441	4,151,213
Rural worker (male)	3,007,018	5,534,006
Urban worker (male)	3,370,306	12,693,717
Slum worker (male)	801,046	3,173,429
Rural worker (female)	150,895	504,294
Urban worker (female)	218,164	1,110,553
Slum worker (female)	52,489	277,638
Rural marginal worker	587,305	1,856,107
Urban marginal worker	202,951	642,206
Slum marginal worker	62,086	269,969
Rural housewives	2,194,338	8,593,283
Urban housewives	2,498,492	11,063,097
Slum housewives	601,629	2,765,774
Rural elders	416,854	315,363
Urban elders	433,189	493,590
Slum elders	100,142	123,397
Rural unemployed	59,291	157,893
Urban unemployed	63,190	195,464
Slum unemployed	15,503	48,866

Table 16 35 Exposure (person-day-mg/cubic meter) for Mathura district (Uttar Prad

Category	RSP	CO
Rural infant	1,724,264	1,649,538
Urban infant	619,515	540,815
Slum infant	145,175	135,204
Rural student	3,935,007	7,568,113
Urban student	1,817,493	6,122,975
Slum student	432,230	1,530,744
Rural worker (male)	3,098,061	5,842,015
Urban worker (male)	1,217,918	4,533,955
Slum worker (male)	289,696	1,133,489
Rural worker (female)	211,331	791,422
Urban worker (female)	77,490	408,642
Slum worker (female)	18,925	102,160
Rural marginal worker	233,256	822,882
Urban marginal worker	22,599	76,352
Slum marginal worker	7,194	33,687
Rural housewives	2,339,720	10,442,141
Urban housewives	757,332	3,693,926
Slum housewives	186,642	923,482
Rural elders	422,632	335,491
Urban elders	158,028	180,874
Slum elders	36,528	45,218
Rural unemployed	274,493	810,071
Urban unemployed	105,531	344,779
Slum unemployed	25,871	86,195

Table 16.36 Exposure (person-day-mg/cubic meter) for Meerut district (Uttar Pradesh

Category	RSP	CO
Rural infant	2,536,197	2,269,524
Urban infant	1,735,584	1,451,021
Slum infant	406,023	362,755
Rural student	5,791,821	10,937,211
Urban student	5,096,432	17,064,562
Slum student	1,212,182	4,266,141
Rural worker (male)	5,110,578	9,431,079
Urban worker (male)	3,366,530	12,244,060
Slum worker (male)	801,989	3,061,015
Rural worker (female)	429,426	1,485,080
Urban worker (female)	214,656	1,084,691
Slum worker (female)	52,041	271,173
Rural marginal worker	649,099	2,075,105
Urban marginal worker	72,015	233,932
Slum marginal worker	22,816	104,013
Rural housewives	3,176,461	12,847,071
Urban housewives	2,064,264	9,461,649
Slum housewives	501,672	2,365,412
Rural elders	622,012	474,898
Urban elders	443,112	499,350
Slum elders	102,425	124,837
Rural unemployed	97,061	265,222
Urban unemployed	71,611	225,847
Slum unemployed	17,583	56,462

Table 16.37 Exposure (person-day-mg/cubic meter) for Muzaffarnagar district (Utta

Category	RSP	CO
Rural infant	2,503,544	2,227,292
Urban infant	951,425	778,882
Slum infant	222,918	194,720
Rural student	5,718,327	10,788,530
Urban student	2,791,933	9,347,056
Slum student	664,101	2,336,764
Rural worker (male)	4,712,995	8,889,737
Urban worker (male)	2,366,104	8,420,832
Slum worker (male)	564,444	2,105,208
Rural worker (female)	588,965	2,038,166
Urban worker (female)	124,473	579,373
Slum worker (female)	30,567	144,843
Rural marginal worker	916,319	2,978,668
Urban marginal worker	57,489	176,180
Slum marginal worker	18,573	83,555
Rural housewives	3,130,959	12,547,803
Urban housewives	1,114,326	4,910,431
Slum housewives	274,280	1,227,608
Rural elders	614,086	466,234
Urban elders	242,735	272,423
Slum elders	56,108	68,106

Table 16 38 Exposure (person-day-mg/cubic meter) for Sagaranpur district (Uttar Pradesh)

Category	RSP	CO
Rural infant	2,008,347	1,795,726
Urban infant	801,772	662,196
Slum infant	187,544	165,549
Rural student	4,586,799	8,663,499
Urban student	2,354,164	7,880,462
Slum student	559,952	1,970,115
Rural worker (male)	3,802,860	7,204,250
Urban worker (male)	1,579,556	5,852,299
Slum worker (male)	375,834	1,463,075
Rural worker (female)	192,592	664,519
Urban worker (female)	74,453	384,932
Slum worker (female)	17,984	96,233
Rural marginal worker	147,648	479,599
Urban marginal worker	10,479	33,048
Slum marginal worker	3,225	14,121
Rural housewives	2,881,960	11,638,853
Urban housewives	1,022,102	4,591,634
Slum housewives	248,145	1,147,908
Rural elders	492,583	375,397
Urban elders	204,691	231,148
Slum elders	47,316	57,787
Rural unemployed	176,740	483,072
Urban unemployed	76,134	240,423
Slum unemployed	18,700	60,106

Table 16.39 Exposure (person-day-mg/cubic meter) for Uttarkashi district (Uttar Pradesh)

Category	*RSP*	*CO*
Rural infant	258,958	217,153
Urban infant	21,314	14,329
Slum infant	5,437	3,582
Rural student	592,854	1,105,392
Urban student	68,733	226,609
Slum student	16,334	56,652
Rural worker (male)	451,873	849,190
Urban worker (male)	53,020	195,614
Slum worker (male)	12,619	48,903
Rural worker (female)	434,316	1,452,148
Urban worker (female)	9,055	31,992
Slum worker (female)	2,182	7,998
Rural marginal worker	145,819	446,311
Urban marginal worker	10,204	23,189
Slum marginal worker	3,112	11,234
Rural housewives	(32,460)	(120,838)
Urban housewives	38,033	103,998
Slum housewives	9,010	25,999
Rural elders	63,711	46,077
Urban elders	5,986	7,167
Slum elders	1,384	1,792

Table 16.40 Exposure (person-day-mg/cubic meter) for Hardwar district (Uttar Pradesh)

Category	*RSP*	*CO*
Rural infant	906,306	797,732
Urban infant	472,494	356,309
Slum infant	110,241	89,077
Rural student	2,070,367	3,892,725
Urban student	1,389,285	4,637,039
Slum student	330,396	1,159,260
Rural worker (male)	1,722,048	3,248,421
Urban worker (male)	933,682	3,503,713
Slum worker (male)	221,969	875,928
Rural worker (female)	91,524	307,645
Urban worker (female)	123,395	606,087
Slum worker (female)	29,390	151,522
Rural marginal worker	58,306	185,417
Urban marginal worker	8,700	25,253
Slum marginal worker	2,729	11,539
Rural housewives	1,331,639	5,267,178
Urban housewives	591,154	2,307,831
Slum housewives	140,437	576,958
Rural elders	222,373	168,123
Urban elders	120,824	137,319
Slum elders	27,931	34,330
Rural unemployed	38,381	103,483
Urban unemployed	21,410	66,794
Slum unemployed	5,255	16,699

Table 16.41 Exposure (person-day-mg/cubic meter) for Firozabad district (Uttar Pradesh)

Category	*RSP*	*CO*
Rural infant	1,315,051	1,185,499
Urban infant	556,071	679,720
Slum infant	130,179	169,930
Rural student	3,001,923	5,673,503
Urban student	1,627,051	5,450,247
Slum student	387,031	1,362,562
Rural worker (male)	2,366,830	4,451,483
Urban worker (male)	1,164,832	4,560,348
Slum worker (male)	276,122	1,140,087
Rural worker (female)	60,152	206,133
Urban worker (female)	56,173	404,125
Slum worker (female)	13,595	101,031
Rural marginal worker	29,542	94,316
Urban marginal worker	6,065	31,310
Slum marginal worker	1,859	11,076
Rural housewives	1,922,677	7,850,423
Urban housewives	695,651	5,427,227
Slum housewives	169,856	1,356,807
Rural elders	322,381	247,990
Urban elders	141,471	160,428
Slum elders	32,705	40,107
Rural unemployed	275,351	753,621

Table 16.42 Exposure (person-day-mg/cubic meter) for Tehrigarhwal district (Uttar Pradesh)

Category	*RSP*	*CO*
Rural infant	637,864	550,311
Urban infant	44,338	26,539
Slum infant	10,345	6,635
Rural student	1,462,774	2,776,540
Urban student	130,885	430,368
Slum student	31,113	107,592
Rural worker (male)	859,880	1,603,711
Urban worker (male)	124,591	399,501
Slum worker (male)	29,907	99,875
Rural worker (female)	1,025,647	3,526,658
Urban worker (female)	9,688	37,952
Slum worker (female)	2,321	9,488
Rural marginal worker	325,237	1,005,641
Urban marginal worker	3,493	8,333
Slum marginal worker	1,000	3,457
Rural housewives	13,756	53,091
Urban housewives	83,708	219,032
Slum housewives	19,902	54,758
Rural elders	157,074	111,384
Urban elders	11,406	14,462
Slum elders	2,640	3,616

Table 16.43 Exposure (person-day-mg/cubic meter) for Etah district (Uttar Pradesh)

Category	*RSP*	CO
Rural infant	2,184,669	1,943,254
Urban infant	511,304	452,328
Slum infant	119,946	113,082
Rural student	4,986,468	9,379,758
Urban student	1,498,214	5,014,661
Slum student	356,401	1,253,665
Rural worker (male)	4,049,715	7,801,658
Urban worker (male)	947,251	3,319,983
Slum worker (male)	226,187	829,996
Rural worker (female)	131,088	449,845
Urban worker (female)	50,263	271,454
Slum worker (female)	12,316	67,863
Rural marginal worker	578,918	1,864,239
Urban marginal worker	43,080	145,320
Slum marginal worker	13,819	65,409
Rural housewives	3,314,448	13,262,811
Urban housewives	651,362	3,215,393
Slum housewives	161,864	803,848
Rural elders	535,516	410,089
Urban elders	130,261	146,772
Slum elders	30,112	36,693

Table 16.44 Exposure (person-day-mg/cubic meter) for Mainpuri district (Uttar Pradesh

Category	*RSP*	CO
Rural infant	1,335,238	1,186,040
Urban infant	236,655	188,527
Slum infant	55,475	47,132
Rural student	3,048,351	5,737,062
Urban student	694,272	2,323,799
Slum student	165,153	580,950
Rural worker (male)	2,385,997	4,582,725
Urban worker (male)	427,334	1,540,492
Slum worker (male)	101,859	385,123
Rural worker (female)	49,487	167,990
Urban worker (female)	18,976	94,426
Slum worker (female)	4,634	23,607
Rural marginal worker	48,524	156,813
Urban marginal worker	1,981	5,706
Slum marginal worker	578	2,319
Rural housewives	1,975,509	7,890,991
Urban housewives	305,917	1,286,058
Slum housewives	75,598	321,514
Rural elders	327,368	249,823
Urban elders	60,362	67,876
Slum elders	13,953	16,969
Rural unemployed	256,085	688,319
Urban unemployed	49,268	154,450
Slum unemployed	12,102	38,613

Health data for Himachal Pradesh

Table 16.45 Health Data of Himachal Pradesh (Shimla)

District	1993	1994	1995
Pulmonary T.B.	1986	3872	3033
Respiratory diseases	83176	134525	147436
Eye diseases	17262	44676	37253

Table 16.46 Health Data of Himachal Pradesh (Sirmaur)

District	1993	1994	1995
Pulmonary T B.	12006	16537	15481
Respiratory diseases	316	480	451
Eye diseases	63907	65619	70928

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Health data for Haryana

Table 16.47 Health data for Ambala district (Haryana)

Disease	1990	1991	1992	1993	1994	1995
Acute upper respiratory in	12196	17405	14987	13025	11522	13521
Other upper respiratory in	95374	29710	42833	46978	38676	41701
Acute lower respiratory in	53193	33970	23612	23217	23479	22663
Pneumonia	1586	1043	2349	2631	2955	2730
Influenza	1677	3715	3961	8648	1746	2099
Emphysema	16394	24272	14151	13517	14704	19616
Pleurisy	585	157	23	18	34	15
Other lower respiratory in	16321	23045	17998	20605	27211	24774

Table 16 48 Health data for Yamuna nagar district (Haryana)

Disease	1990	1991	1992	1993	1994	1995
Acute upper respiratory in	0	3641	8554	2547	3495	2002
Other upper respiratory in	0	43848	45144	39431	37237	28773
Acute lower respiratory in	0	17372	22437	22761	22224	18996
Pneumonia	0	1951	6327	3721	3216	4232
Influenza	0	0	18002	4162	9663	4141
Emphysema	0	16859	19272	17686	17927	10397
Pleurisy	0	16	487	5	66	1874
Other lower respiratory in	0	25744	11423	26131	23045	25633

Table 16 49 Health data for Kurukesthra district (Haryana)

Disease	1990	1991	1992	1993	1994	1995
Acute upper respiratory in	4348	1022	1121	840	1538	784
Other upper respiratory in	37774	24428	25274	18606	22071	12791
Acute lower respiratory in	16188	5819	5421	7584	7112	5205
Pneumonia	772	113	231	199	173	106
Influenza	246	0	0	0	0	0
Emphysema	5446	19157	10800	4738	5849	1663
Pleurisy	25	29	0	25	12	0
Other lower respiratory in	12368	14980	5896	4808	6170	7520

Table 16 50 Health data for Karnal district (Haryana)

Disease	1990	1991	1992	1993	1994	1995
Acute upper respiratory infection	9534	24512	19668	5542	7522	4391
Other upper respiratory infection	87632	33018	41878	37561	37823	35313
Acute lower respiratory infection	39449	10637	20421	22166	12664	19703
Pneumonia	4133	21409	2796	1264	935	1774
Influenza	311	83	1058	1541	1401	1358
Emphysema	9114	19100	17069	13141	9922	11190
Pleurisy	228	115	80	205	8	18
Other lower respiratory infection	8897	6547	9691	11713	20290	4700

Table 16 51 Health data for Bhiwani district (Haryana)

Disease	1990	1991	1992	1993	1994	1995
Acute upper respiratory infection	18801	2081	2127	1970	1601	3474
Other upper respiratory infection	20939	33269	32234	30466	29005	26835
Acute lower respiratory infection	29489	17484	15389	15091	15230	13771
Pneumonia	2690	3041	2947	1982	841	1758
Influenza	0	0	17	5	0	0
Emphysema	20682	26387	13965	14540	14118	18165
Pleurisy	86	139	286	55	11	343
Other lower respiratory infection	12472	8197	14375	14247	14560	13433

Table 16 52 Health data for Faridabad district (Haryana)

Disease	1990	1991	1992	1993	1994	1995
Acute upper respiratory infection	26370		16219	17371	24131	21477
Other upper respiratory infection	39609	83968	97922	83544	66642	73008
Acute lower respiratory infection	49489	46801	40759	48377	49334	43315
Pneumonia	5000	5958	5705	7534	4978	5050
Influenza	5905	2797	726	5895	1988	114
Emphysema	22982	42139	33258	27248	36546	31719
Pleurisy	97	1736	111	77	105	117
Other lower respiratory infection	50418	58731	49570	37266	36823	24931

Table 16 53 Health data for Gurgaon district (Haryana)

Disease	1990	1991	1992	1993	1994	1995
Acute upper respiratory infection	6529	4463	2922	3168	1970	8014
Other upper respiratory infection	28265	23668	32497	26871	36830	28265
Acute lower respiratory infection	26740	15576	25915	16647	10933	14220
Pneumonia	1566	2223	1340	756	518	476
Influenza	39	23	10	12	0	5
Emphysema	13495	23265	10729	10546	13933	10467
Pleurisy	205	236	226	392	60	83
Other lower respiratory infection	25711	14387	17276	14258	14496	15352

Table 16.54 Health data for Hissar district (Haryana)

Disease	1990	1991	1992	1993	1994	1995
Acute upper respiratory infection	14049	12274	12884	12355	10227	15690
Other upper respiratory infection	80490	61233	77116	55095	61214	38339
Acute lower respiratory infection	28192	27044	27784	23047	26356	21976
Pneumonia	2382	2795	2371	2447	2763	1620
Influenza	2486	2769	573	982	453	2230
Emphysema	30596	27388	24875	19666	21733	17523
Pleurisy	142	370	102	22	30	43
Other lower respiratory infection	12354	22756	15100	22753	20283	18093

Table 16 55 Health data for Jind district (Haryana)

Disease	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*
Acute upper respiratory infection	10572	9146	3737	19946	24346	31613
Other upper respiratory infection	34600	24469	34982	15468	19405	27225
Acute lower respiratory infection	26522	17375	21253	14473	23901	29147
Pneumonia	3441	1580	1131	716	752	850
Influenza	0	0	0	452	45	0
Emphysema	18229	22156	9289	11573	16083	26276
Pleurisy	0	3	1	97	113	78
Other lower respiratory infection	1809	4904	3836	7575	2718	10253

Table 16.56 Health data for Mohindergarh district (Haryana)

Disease	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*
Acute upper respiratory infection	2458	1192	3561	1575	1026	1785
Other upper respiratory infection	30785	21385	17691	12321	13584	10193
Acute lower respiratory infection	18310	6662	6066	7599	10640	6409
Pneumonia	4670	3221	4864	2472	993	1138
Influenza	0	0	0	0	0	234
Emphysema	10494	18812	9011	6881	7260	4083
Pleurisy	13	0	35	66	11	6
Other lower respiratory infection	6125	12640	4140	3545	4798	2864

Table 16 57 Health data for Panipat district (Haryana)

Disease	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*
Acute upper respiratory infection	0	4031	2153	2657	3015	2484
Other upper respiratory infection	11	18488	17282	15438	16751	18414
Acute lower respiratory infection	6000	22901	12048	32499	25107	23471
Pneumonia	1433	738	519	210	353	302
Influenza	2943	419	0	1883	253	0
Emphysema	17614	0	3983	9583	8481	9304
Pleurisy	536	0	12	0	0	0
Other lower respiratory infection	920	0	1632	2829	5918	9917

Table 16.58 Health data for Rewari district (Haryana)

Disease	1990	1991	1992	1993	1994	1995
Acute upper respiratory infection	0	6713	0	2511	8698	4974
Other upper respiratory infection	34	1691	36224	12287	13599	12571
Acute lower respiratory infection	3658	15319	14456	9064	10394	11802
Pneumonia	0	1309	1094	1289	1126	1562
Influenza	6303	0	0	0	0	2008
Emphysema	8165	0	11783	3599	4377	9254
Pleurisy	436	0	12	72	19	0
Other lower respiratory infection	687	0	14388	7314	5409	12021

Table 16.59 Health data for Rohtak district (Haryana)

Disease	1990	1991	1992	1993	1994	1995
Acute upper respiratory infection	12148	9255	7195	12605	5082	1250
Other upper respiratory infection	59115	56808	54591	58268	58127	72811
Acute lower respiratory infection	18600	23573	16087	35631	10867	18245
Pneumonia	1506	1322	2643	1693	637	952
Influenza	0	250	3261	290	2909	50
Emphysema	19292	13950	12914	17526	14581	14486
Pleurisy	6	0	2	6	17	13
Other lower respiratory infection	10226	32951	24605	11885	25426	

Table 16 60 Health data for Sirsa district (Haryana)

Disease	1990	1991	1992	1993	1994	1995
Acute upper respiratory infection	2917	1546	1466	1476	2835	1456
Other upper respiratory infection	31790	19638	27627	29447	31264	22594
Acute lower respiratory infection	8323	4645	4436	5175	5725	4561
Pneumonia	471	233	474	513	332	273
Influenza	7	0	0	0	138	91
Emphysema	5742	6728	5443	7383	4773	7098
Pleurisy	9	10	0	49	166	2
Other lower respiratory infection	3918	87	8939	5685	6905	2444

Table 16.61 Health data for Sonepat district (Haryana)

Disease	1990	1991	1992	1993	1994	1995
Acute upper respiratory infection	6555	8365	5853	12937	9668	7758
Other upper respiratory infection	39281	60082	19636	43545	36006	30992
Acute lower respiratory infection	19341	32168	13297	23740	57384	46841
Pneumonia	1928	1565	603	602	656	280
Influenza	0	3	3	0	0	0
Emphysema	5121	0	20113	11780	13231	18710
Pleurisy	27	0	1268	30	22	13
Other lower respiratory infection	9817	0	11300	20771	12301	8189

Health data for Rajasthan

Table 16.62 Health data for Alwar district (Rajasthan)

Disease	*1970*	*1975*	*1977*	*1980*	*1992*
Asthma	11645	49826	7643	3763	
Influenza	8285	7629	1767	2312	10901
Pulmonary Tuberculosis	13950	20421	86694	18491	8584
Acute Upper Respiratory Infection	9278	12659	19	18491	59084
Pneumonia	13950	20421	86694	18491	21977
Acute Lower Respiratory Infection	40666	42946	7978	74790	55580
Ephysema	972	36074	36679	189	31204

Table 16.63 Health data for Bharatpur district (Rajasthan)

Disease	*1970*	*1975*	*1977*	*1980*	*1992*
Asthma	8950	26742	5685	2542	
Influenza	1632	841	1243	659	2344
Pulmonary Tuberculosis	9114	9440	52788	11371	7222
Acute Upper Respiratory Infection	6558	7472	19	11371	47742
Pneumonia	9114	9440	52788	11371	17085
Acute Lower Respiratory Infection	25498	30329	1258	75493	52296
Ephysema	673	30169	24326	104	20715

Table 16 64 Health data for Churu district (Rajasthan)

Disease	*1970*	*1975*	*1977*	*1980*	*1992*
Asthma	6608	28987	5178	2826	
Influenza	1918	61	2969	1717	9432
Pulmonary Tuberculosis	8068	6498	35949	2257	20716
Acute Upper Respiratory Infection	3139	5262	35	2257	47080
Pneumonia	8068	6498	35949	2257	20094
Acute Lower Respiratory Infection	23471	25166	551	27939	47347
Ephysema	18	14207	9594	0	25513

Table 16.65 Health data for Dholpur district (Rajasthan)

Disease	1970	1975	1977	1980	1992
Asthma	10088	18859	1584	8926	
Influenza	1544	630	1258	1668	3055
Pulmonary Tuberculosis	3473	1481	19030	18068	1434
Acute Upper Respiratory Infection	1571	706	7	18068	14517
Pneumonia	3473	1481	19030	18068	5908
Acute Lower Respiratory Infection	70181	17857	0	56426	28117
Ephysema	5	8501	33225	493	6283

Table 16 66 Health data for Ganganagar district (Rajasthan)

Disease	1970	1975	1977	1980	1992
Asthma	9932	39490	6560	232	
Influenza	2307	2180	1424	575	3901
Pulmonary Tuberculosis	1717	7891	34330	4403	11358
Acute Upper Respiratory Infection	6742	8405	28	4403	67831
Pneumonia	1717	7891	34330	4403	14474
Acute Lower Respiratory Infection	17870	35756	80	28923	68925
Ephysema	67	26120	21534	56	31125

Table 16 67 Health data of the district Jhunjhnu (Rajasthan)

Disease	1970	1975	1977	1980	1992
Asthma	35882	118333	34920	646	
Influenza	9955	3478	3232	3774	13399
Pulmonary Tuberculosis	30801	28999	148653	14184	124230
Acute Upper Respiratory Infection	23475	34996	733	14184	134796
Pneumonia	30801	28999	148653	14184	26409
Acute Lower Respiratory Infection	108639	196143	6562	76736	75447
Ephysema	527	68882	60992	129	79837

Table 16.68 Health data for S Modhavpur district (Rajasthan)

Disease	1970	1975	1977	1980	1992
Asthma	9252	12824	4512	0	
Influenza	4802	332	8	1030	4615
Pulmonary Tuberculosis	6776	3394	38417	5149	7879
Acute Upper Respiratory Infection	4501	4215	22	5149	26726
Pneumonia	6776	3394	38417	5149	17210
Acute Lower Respiratory Infection	32926	36458	15	45469	32605
Ephysema	19	15137	20255	29	26109

Table 16.69 Health data for Sikar district (Rajasthan)

Disease	1970	1975	1977	1980	1992
Asthma	10272	28299	9904	8509	
Influenza	5468	2534	1648	42117	4257
Pulmonary Tuberculosis	11276	10787	47233	4164	9105
Acute Upper Respiratory Infection	4017	8243	120	4164	61760
Pneumonia	11276	10787	47233	4164	19050
Acute Lower Respiratory Infection	19590	34994	2754	4783	51868
Ephysema	82	24242	864	8531	30846

Table 16.70 Health data for Dausa district (Rajasthan)

Disease	1970	1975	1977	1980	1992
Asthma	District not formed				
Influenza					1751
Pulmonary Tuberculosis					9446
Acute Upper Respiratory Infection					3039
Pneumonia					13665
Acute Lower Respiratory Infection					25364
Ephysema					9663

Health data for Uttar Pradesh

Table 16 71. Health data on Pulmonary Tuberculosis for the state Uttar Pradesh

Uttar Pradesh	*1993*	*1994*	*1995*	*1996*
Agra	35015	178072	18828	24713
Aligarh	29461	53944	13070	28418
Firozabad	31871	57304	17310	23747
Haridwar	32912	26299	8101	16175
Muzzaffarnagar	18577	33421	13428	20404
Meerut	21255	43799	13321	14491
Bulandshahar	23447	49538	14957	16161
Ghaziabad	49474	81065	21757	37516
Etawah	46715	59128	24902	23741
Tehri Garhwal	29710	54830	16521	25584
Dehradun	106048	113238	10613	25562
Uttarkahsi	22630	32991	5830	17091
Sharanpur	57434	84628	15850	30079
Mathura	84223	143219	31738	259180

Health data for Delhi

Table 16 72 Health data of Delhi

Disease	*1989*	*1990*	*1991*	*1992*	*1993*	*1994*
Acute Respiratory Infections	7388715	8929103	135619	118589	143608	138453
Pneumonia	499296	434065	15145	19346	21139	20033
Pulmonary Tuberculosis	1040772	1131743	49839	56279	74732	61263

CHAPTER 17

Recommendations for further research

- The exposure study for districts other than Delhi shall be undertaken based on primary data on time budget and air pollution level both indoor and outdoor.

- This type of study should made a regular activities so that dose response curve can be applied in future.

- Comprehensive air quality measurements both indoor and outdoor should be undertaken to capture locality variations.

- Studies should be undertaken of the physical and chemical characteristics of RSP in a number of different locations, including busy traffics, urban background and rural areas. Particle size distributions by mass and number, particle morphology, surface properties and the adsorption of gases and acidic components should be included in such studies, with particular attention to ultrafine particles.

- Exposure calculations should be undertaken considering mass and number distribution of RSP.

- The toxicological properties of ultrafine particles should be studied. The possible toxicological interactions between such particles and gaseous pollutants are especially worthy to study.

- The practicability of carrying out controlled human exposures to a broader range of RSP components, observing short-term effects on lung function or symptoms, should be considered.

- Opportunities for exploring chronic effects of long-term exposure to RSP, through the use of routinely available mortality or morbidity statistics or follow-up of special surveys should be considered.

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SECTION 4

Energy and air pollution emission accounts

Vikram Dayal, Ajay Sharma, and R Uma

CHAPTER 18

Introduction

Emissions of some of the most important pollutants will mainly depend on energy use. The energy use accounts are obviously an excellent starting point for emissions to air. Emissions will depend on the composition of the energy commodity combusted and the conditions of combustion. Combustion emissions are calculated by combining the fuel consumption distributed between emission sources and economic sectors with fuel, source, sector and pollutant specific emission factors.

There are several applications of the emission accounts. They can be used for setting targets to reduce emissions. Emission accounts are the obvious starting point to evaluate technical and economical measures to reduce or stabilise emissions. The emission accounts can be linked to economic models for projections and cost/benefit analyses, and may indicate how taxes may influence future emissions.

Objectives

- Identify energy related activities contributing to emissions in the Yamuna sub-basin.
- Estimate energy consumption in industry, transport, urban and rural households, and thermal power generation.
- Estimate emissions of air pollutants due to energy consumption in industry, transport, urban and rural households, and thermal power generation.

CHAPTER 19

Methodology

The methodology involves the following steps:

1) Divide the region into grids
2) Establish the source inventory; classifying sources into the following categories: transport, domestic, power and industry.
3) For each source, using norms and averages, estimate fuel consumption
4) Use the identity: fuel consumed = fuel supplied, normalising estimates of fuel consumption from the demand side (which are more disaggregated) with figures of total supply of fuel on the supply side (which are more aggregated).
5) Apply emission factor to fuel consumption

Transport

Number of vehicles of each type × vehicle utilization = Km travelled ···(1)

Km travelled × fuel efficiency = fuel consumption ···(2)

Fuel consumption × emission factor = emissions ···(3)

Domestic

Persons × per capita consumption = energy consumption ···(4)

Energy consumption × emission factor = emissions ···(5)

Power

Power generated × specific coal consumption
= coal consumption ...(6)

Coal consumption × emission factor
= emission ...(7)

TSP: coal consumption × emission × $(1-\eta)$ = emissions

where eta is the efficiency of the electrostatic precipitator

Industry

Production × emission factor = emissions ...(8)

Source inventory

The first step in predicting air quality of a region is to build an inventory of air pollution emitting sources.

Transport

Table 20.1. Annual average vehicle utilization

Mode	km/year
2 wheelers	4,928
Cars	9,855
3 wheeler	43,800
Taxis	31,025
Buses	82,500
Trucks	54,828
LCVs	36,500

Source. Engineering Consultants Private Limited 1987

Haryana

Table 20.2. District-wise population of vehicles in Haryana: 1993

District	2 wheelers	Jeeps	Cars	3 wh pass	Public service vehicles	Goods
Ambala	64,625	1,332	6,747	393	1,241	2,391
Yamunanagar	25,385	97	2,103	954	405	1,655
Kurukshetra	20,764	334	1,340	218	140	1,631
Kaithal	14,687	280	654	31	524	1,713
Karnal	36,477	1,499	1,800	232	1,897	2,214
Panipat	25,463	331	1,538	218	446	1,986
Sonipat	18,432	304	1,234	465	1,804	3,930
Rohtak	20,195	828	2,410	54	109	2,826
Faridabad	89,084	8,626	10,006	1,913	105	14,919
Gurgaon	21,994	1,404	4,370	2,342	789	6,378
Rewari	9,741	216	360	58	541	799
Mahendragarh	4,929	265	121	23	296	668
Bhiwani	11,261	527	708	131	884	2,183
Jind	8,330	182	554	198	550	1,164
Hissar	44,991	2,060	2,097	1,287	1,299	3,928
Sirsa	26,694	3,359	2,159	126	285	2,280

Source. Government of Haryana 1996, p.454

Table 20.3. Number of vehicles in Haryana: 1992 to 1995

As on	All vehicles	3 wh pass	3 wh goods	taxis	buses	trucks	2 wh	cars	jeeps
31 Mar 1992	700,238	6,312	12,975	519	12,504	49,266	371,409	35,102	18,471
31 Mar 1993	737,537	6,804	3,162	1,258	7,628	50,360	395,758	35,162	19,629
31 Mar 1994	836,706	9,397	3,690	123	8,788	49,761	446,740	41,054	21,736
31 Mar 1995	952,434	11,336	3,690	190	10,831	58,514	520,192	48,509	22,512

Source. Ministry of Surface Transport 1995, pp. 17, 19, 21, 23

Table 20.4. District-wise population of vehicles in Himachal: 1993

District	2 wh	Jeeps	Cars	3 wh pass	Buses	Trucks	LCV	3wh goods	Goods
Shimla	3512	863	1530		294	962	241	1	2,391
Sirmaur	3443	235	505	9	109	1016	109	2	1,655
Solan	6717	664	1177		193	2270	138	2	1,631

Source. Government of Himachal Pradesh, unpublished note

Table 20.5. Number of vehicles in Himachal Pradesh: 1992 to 1995

As on	All vehicles	3 wh pass	3 wh goods	taxis	buses	trucks	2 wh	cars	jeeps
31 Mar 1992	75,180	137	17	3,704	2,886	13,746	40,135	6,361	4,273
31 Mar 1993	82,684	346	35	4,504	2,817	14,426	44,215	7,184	4,518
31 Mar 1994	93,835	341	39	5,714	3,611	15,956	49,744	8,176	5,155
31 Mar 1995	104,939	835	56	7,209	4,040	17,400	54,985	9,165	5,461

Source. Ministry of Surface Transport 1995, pp. 17, 19, 21, 23

Table 20.6. District-wise population of vehicles in Rajasthan: 1993

District	2 wheelers	Private cars and jeeps	Contract and taxi carriages	Buses	Public and private carriers
Alwar	39,278	2,749	507	1,044	4,617
Bharatpur	21,436	2,042	137	970	2,751
Jaipur	248,929	38,199	7,174	10,801	19,054
Jhunjhunu	6,621	2,271	591	979	1,842
S.Madhopur	7,502	1,142	125	624	1,379
Sikar	6,807	2,916	805	963	1,577
Dhaulpur	3,294	313	36	211	290
Dausa	1,476	180	19	14	114
Churu	1,686	3,505	1,009	829	1,156
Ganganagar	41,443	8,961	803	1,617	6,882

Source. Government of Rajasthan. 1996 p. 210

Table 20.7. Number of vehicles in Rajasthan: 1992 to 1995

As on	All vehicles	3 wh pass	3 wh goods	taxis	buses	trucks	2 wh	cars	jeeps
31 Mar 1992	1,204,463	22,076	839	9,897	25,134	73,056	778,966	57,553	42,669
31 Mar 1993	1,320,021	23,586	979	10,973	26,944	78,276	857,370	60,874	46,841
31 Mar 1994	1,444,061	25,535	1,177	11,658	29,194	82,992	945,743	65,035	52,069
31 Mar 1995	1,584,776	27,909	1,437	12,350	31,455	89,158	1,047,847	70,607	57,276

Source. Ministry of Surface Transport 1995, pp. 17, 19, 21, 23

Table 20.8. Number of vehicles in Uttar Pradesh: 1992 to 1995

As on	All vehicles	3 wh pass	3 wh goods	taxis	buses	trucks	2 wh	cars	jeeps
31 Mar 1992	2,150,628	31,993	5,206	18,442	24,779	77,190	1,521,301	106,021	45,094
31 Mar 1993	2,359,009	36,288	5,673	17,850	26,906	82,656	1,642,884	106,565	51,906
31 Mar 1994	2,448,596	9,397	5,379	55,366	25,432	78,518	1,736,374	108,345	49,739
31 Mar 1995	2,544,215	39,258	5,820	17,854	26,788	75,851	1,815,358	118,178	51,624

Source. Ministry of Surface Transport 1995, pp. 17, 19, 21, 23

Table 20.9. District-wise population of vehicles in Uttar Pradesh: 1994

District	2 wheelers	Cars	Taxis	Buses	Goods HCVs	Goods LCVS
Agra	148,210	9,890	3,656	973	974	3,338
Aligarh	40,372	1,629	50	740	1,990	0
Bulandshahr	20,107	736	407	757	2,745	0
Dehradun	69,412	8,298	4,408	808	2,352	558
Etawah	16,200	370	470	435	354	12
Ghaziabad	31,030	3,122	730	869	1,522	985
Mathura	31,418	3,421	44	321	1,226	0
Meerut	74,164	6,723	1,074	1,568	4,219	910
Muzaffar Nagar	2,706	2,327	138	524	175	1,669
Sahranpur	33,229	1,802	217	669	1,125	230
Haridwar	21,463	1,798	1,131	201	382	307
Firozabad	7,070	396	868	138	137	426
Etah	10,129	1,193	161	422	920	0

Source. Government of Uttar Pradesh, unpublished note

Delhi

Table 20.10. Registered vehicles in Delhi: 1992 to 1995

Mode	1992	1993	1994
2 wheelers	1,317,180	1,403,050	1,492,201
Cars and jeeps	440,166	477,783	522,264
3 wheelers	67,128	70,459	72,102
Taxis	10,694	11,365	11,846
Buses	20,201	23,221	24,211
Goods	107,629	111,277	116,379

Source. Ministry of Surface Transport 1995, pp. 18, 20, 22

Domestic

Table 20.11. Per capita consumption of cooking fuels (kg/capita/day)

Region	Rural/ urban	Dung	Coal/ coke	Char- coal	Cooking gas	Wood	Kero- sene	Others
Trans-Gangetic	Rural	1.88	0.35	0.24	0.07	0.98	0.11	0.68
Western Himalayan	Rural	1.86	0.35	0.24	0.07	0.97	0.11	0.67
Central Plateau	Rural	2.73	0.51	0.35	0.10	1.41	0.17	0.98
Western dry	Rural	1.91	0.36	0.24	0.07	0.99	0.12	0.69
Upper Gangetic	Rural	2.31	0.43	0.30	0.08	1.19	0.14	0 83
All regions	Urban	2.28	0.51	0.35	0.10	1.42	0.17	1.02

Note. Estimated from Joshi and Sinha's (1993) estimates of useful energy consumption in different agro-climatic regions

Table 20.12. District-wise rural and urban population in the Yamuna sub-basin: 1992/93

District	Rural/urban	population
Ambala	Rural	748,199
Ambala	Urban	412,609
Kurukshetra	Rural	506,997
Kurukshetra	Urban	160,192
Karnal	Rural	667,782
Karnal	Urban	252,849
Jind	Rural	828,930
Jind	Urban	172,051
Sonipat	Rural	599,529
Sonipat	Urban	185,032
Panipat	Rural	631,041
Panipat	Urban	235,243
Rohtak	Rural	1,479,105
Rohtak	Urban	400,632
Faridabad	Rural	789,612
Faridabad	Urban	745,731
Gurgaon	Rural	949,316
Gurgaon	Urban	241,853
Mahendragarh	Rural	620,721
Mahendragarh	Urban	87,969
Bhiwani	Rural	980,246
Bhiwani	Urban	204,302
Hissar	Rural	1,512,312
Hissar	Urban	404,872
Sirsa	Rural	740,358
Sirsa	Urban	198,720
Rewari	Rural	548,872
Rewari	Urban	98,944
Kaithal	Rural	727,585
Kaithal	Urban	125,385
Yamunanagar	Rural	566,384
Yamunanagar	Urban	287,822
Shimla	Rural	510,593
Shimla	Urban	131,091
Sirmaur	Rural	355,057
Sirmaur	Urban	39,567
Solan	Rural	348,165
Solan	Urban	49,139
Alwar	Rural	2,054,023
Alwar	Urban	332,888
Bharatpur	Rural	1,383,123
Bharatpur	Urban	333,418
Jaipur	Rural	2,968,240
Jaipur	Urban	1,940,060

District	Rural/urban	population
Sikar	Rural	1,512,634
Sikar .	Urban	402,762
Dhaulpur	Rural	645,066
Dhaulpur	Urban	133,892
Churu	Rural	1,140,327
Churu	Urban	463,583
Ganganagar	Rural	2,152,110
Ganganagar	Urban	573,828
Agra	Rural	1,704,433
Agra	Urban	1,154,792
Aligarh	Rural	2,564,532
Aligarh	Urban	861,087
Bulandshahr	Rural	2,345,836
Bulandshahr	Urban	616,106
Dehradun	Rural	530,267
Dehradun	Urban	535,755
Etawah	Rural	1,861,393
Etawah	Urban	346,825
Ghaziabad	Rural	1,512,925
Ghaziabad	Urban	1,297,357
Mathura	Rural	1,533,982
Mathura	Urban	473,156
Meerut	Rural	2,256,765
Meerut	Urban	1,326,770
Muzaffar Nagar	Rural	2,227,615
Muzaffar Nagar	Urban	726,732
Sahranpur	Rural	1,787,008
Sahranpur	Urban	612,842
Uttarkashi	Rural	231,200
Uttarkashi	Urban	17,939
Haridwar	Rural	806,886
Haridwar	Urban	361,833
Firozabad	Rural	1,169,763
Firozabad	Urban	423,590
Tehri Garhwal	Rural	568,783
Tehri Garhwal	Urban	34,189
Etah	Rural	1,943,282
Etah	Urban	390,018
Mainpuri	Rural	1,187,807
Mainpuri	Urban	180,730
Delhi	Rural	986,347
Delhi	Urban	8,804,841

Source. Projected from population figures in Census of India 1991

Table 20.13. Percentage of population consuming different cooking fuels in each district

District	Rural/urban	*Dung*	*Coal/coke*	*Charcoal*	*Cooking gas*	*Wood*	*Kerosene*	*Others*
Ambala	Rural	40.7	0.2	0.9	5.2	45.2	6.0	1.1
Ambala	Urban	6.0	1.3	1.9	62.4	9.5	16.9	1.1
Kurukshetra	Rural	74.9	0.1	0.5	2.7	17.8	1.9	1.0
Kurukshetra	Urban	12.9	0.9	1.0	48.9	16.3	18.3	0.9
Karnal	Rural	66.4	0.1	0.8	2.9	26.7	1.3	0.8
Karnal	Urban	14.0	0.9	1.3	49.5	15.8	17.0	0.7
Jind	Rural	33.8	0.1	0.7	0.5	63.6	0.4	0.7
Jind	Urban	17.8	4.8	2.5	31.1	34.1	8.4	0.5
Sonipat	Rural	30.3	0.1	0.5	3.7	62.0	2.0	1.0
Sonipat	Urban	17.9	1.1	3.0	46.6	17.8	11.8	0.4
Panipat	Rural	45.7	0.2	0.3	2.7	48.0	2.0	0.7
Panipat	Urban	11.3	1.7	2.4	44.6	16.3	21.5	1.2
Rohtak	Rural	37.2	0.1	0.3	1.6	58.9	0.3	1.4
Rohtak	Urban	19.8	0.9	1.8	49.4	18.1	8.4	0.7
Faridabad	Rural	21.4	0.1	0.3	1.0	75.7	0.6	0.6
Faridabad	Urban	12.5	0.7	1.3	34.8	19.7	29.3	1.1
Gurgaon	Rural	38.4	0.3	0.6	3.0	54.8	1.6	1.1
Gurgaon	Urban	12.6	1.2	1.4	51.8	20.5	11.0	0.9
Mahendragarh	Rural	5.6	0.0	0.3	0.5	91.5	0.2	1.7
Mahendragarh	Urban	3.8	0.0	1.1	29.5	58.1	6.5	0.3
Bhiwani	Rural	16.9	0.1	0.2	0.8	80.5	0.4	0.9
Bhiwani	Urban	16.6	1.0	2.9	31.1	34.0	12.2	0.9
Hissar	Rural	6.4	0.1	0.5	1.0	90.6	0.7	0.5
Hissar	Urban	6.8	1.3	2.1	38.1	37.3	12.4	0.5
Sirsa	Rural	2.4	0.1	0.0	1.4	94.5	0.7	0.6
Sirsa	Urban	2.6	0.6	1.2	30.5	46.2	17.8	0.5
Rewari	Rural	14.6	0.6	0.2	1.3	77.3	1.9	3.9
Rewari	Urban	9.3	3.7	3.1	33.8	33.1	16.1	0.6
Kaithal	Rural	66.5	0.2	0.4	0.8	29.8	0.8	1.0
Kaithal	Urban	28.7	2.1	2.7	23.7	23.5	17.3	0.5
Yamunanagar	Rural	43.7	0.2	0.2	2.7	48.7	2.4	1.0
Yamunanagar	Urban	8.6	0.5	1.8	40.9	24.8	21.9	0.7
Shimla	Rural	0.0	0.1	0.7	2.4	88.4	7.5	0.2
Shimla	Urban	0.1	0.6	0.4	47.2	5.3	44.1	0.7
Sirmaur	Rural	0.1	0.0	0.8	1.6	91.2	5.1	0.2
Sirmaur	Urban	0.1	0.1	0.7	44.4	18.4	34.3	1.1
Solan	Rural	0.1	0.1	0.9	4.0	83.4	10.4	0.3
Solan	Urban	0.1	0.5	0.3	49.5	7.4	40.7	0.6
Alwar	Rural	16.1	0.1	0.3	0.7	78.5	0.9	3.4
Alwar	Urban	5.1	0.2	1.9	32.5	36.3	22.6	0.7
Bharatpur	Rural	36.7	0.0	0.3	0.4	61.8	0.3	0.4
Bharatpur	Urban	12.0	0.9	2.5	24.4	53.8	5.6	0.6
Jaipur	Rural	4.5	0.1	0.5	0.6	92.9	0.7	0.6
Jaipur	Urban	1.6	0.8	3.3	33.0	33.8	26.7	0.4

Table 20.13 continued...

District	Rural/urban	Dung	Coal/coke	Charcoal	Cooking gas	Wood	Kerosene	Others
Jhunjhunu	Rural	0.2	0.0	0.3	0.7	97.4	0.3	0.8
Jhunjhunu	Urban	0.2	0.2	2.1	19.4	69.2	6.3	1.0
S. Madhopur	Rural	31.4	0.1	0.6	0.4	66.1	0.4	0.8
S. Madhopur	Urban	4.7	2.0	4.6	18.7	59.9	7.2	1.3
Sikar	Rural	0.4	0.0	0.2	0.4	98.3	0.3	0.2
Sikar	Urban	0.6	0.4	4.3	18.2	70.6	5.3	0.3
Dhaulpur	Rural	14.7	0.1	0.2	0.4	83.3	0.2	0.9
Dhaulpur	Urban	5.0	0.8	3.6	16.7	67.4	4.9	0.9
Churu	Rural	2.5	0.0	0.2	0.1	96.4	0.3	0.3
Churu	Urban	1.2	0.5	2.4	13.8	74.5	6.6	0.5
Ganganagar	Rural	0.8	0.0	0.1	0.3	97.9	0.3	0.3
Ganganagar	Urban	1.5	1.1	1.4	18.3	58.4	17.9	0.5
Agra	Rural	28.7	0.1	0.4	0.4	68.9	0.1	1.2
Agra	Urban	8.5	7.1	5.0	30.2	41.1	5.7	1.3
Aligarh	Rural	50.6	0.1	0.3	0.4	47.6	0.1	0.7
Aligarh	Urban	16.1	4.6	3.8	20.8	46.2	4.6	0 9
Bulandshahr	Rural	69.2	0.4	0.2	0.3	28.2	0.2	1.2
Bulandshahr	Urban	19.9	3.6	3.0	20.5	46.6	3.6	0.9
Dehradun	Rural	0.4	0.1	0.6	15.4	70.8	10.8	0.5
Dehradun	Urban	0.5	0.5	0.7	54.1	13.1	29.7	0.9
Etawah	Rural	12.9	0.0	0.1	0.5	78.6	0.2	7.4
Etawah	Urban	1.0	0.6	1.7	15.5	74.6	4.8	0.9
Ghaziabad	Rural	82 8	0.2	0.2	1.7	11.6	1.8	1.1
Ghaziabad	Urban	24.2	4 8	2.1	35.5	14.4	16.9	0.8
Mathura	Rural	27.1	1.7	0.3	1.3	66.5	0.3	2.1
Mathura	Urban	10.0	4.3	3.1	21.5	50.7	7.6	1.2
Meerut	Rural	88.5	0.3	0.2	1.0	8.4	0.2	0.8
Meerut	Urban	33.1	4.2	1.7	31.5	18.2	9.5	0.8
Muzaffar Nagar	Rural	87.6	0.2	0.2	0.6	9.4	0.3	1.2
Muzaffar Nagar	Urban	30.7	2 2	2.0	23.6	32.4	6.7	1.0
Sahranpur	Rural	51.2	0.3	0.4	0.8	45.4	0.3	1.3
Sahranpur	Urban	8.0	3.8	2 3	32.3	42.3	8.6	1.3
Uttarkashi	Rural	43 6	0.3	0.3	0.6	52.9	0.7	1.2
Uttarkashi	Urban	10.0	5 0	2 6	25.6	39.7	14.8	1.0
Haridwar	Rural	35.0	0.1	0.5	1.9	59.2	1.4	1 5
Haridwar	Urban	3.3	3.2	1.6	47.6	29.5	12.9	1.2
Firozabad	Rural	28.3	0.4	0 2	0.4	68.9	0.1	1.7
Firozabad	Urban	3.5	18.4	4.8	21.6	47.8	2.3	0.8
Tehri Garhwal	Rural	0.5	0.1	0.5	2.5	89.4	5.0	1.5
Tehri Garhwal	Urban	0.2	0.3	0 2	38.1	7.6	47.8	3.3
Etah	Rural	45.8	0.1	0.3	0.2	52.4	0.1	1.0
Etah	Urban	6.5	3.4	1.7	17.3	68.0	1.6	0.7
Mainpuri	Rural	53.7	0.1	0.2	0.3	44.5	0.1	0.9
Mainpuri	Urban	5.0	0.8	2.3	21.7	63.1	4.7	1.1
Delhi	Rural	24.1	0.5	1.0	18.0	16.0	39.4	0.4
Delhi	Urban	2.9	0.9	0.4	49.2	3.6	41.8	0.4

Source. Census of India 1991

Power

Power plants in the Yamuna sub-basin:

Steam thermal

- Badarpur
- I.P.Station
- Rajghat
- Faridabad
- Panipat
- Harduaganj B
- Harduaganj A
- Dadri

Gas thermal

- Dadri
- Auraiya
- DESU

Table 20.14. Power generation by the different thermal power plants in the Yamuna sub-basin (GWh/year)

Power station	*1992/93*	*1993/94*	*1994/95*
Steam thermal			
Badarpur 1-5	4581	4449	4508
I.P Station	1380	1146	1112
Rajghat 1-2	564	618	831
Faridabad 1-3	894	741	786
Panipat 1-5	2667	2145	2409
Harduaganj B 1-7	939	1011	752
Harduaganj A	0	0	0
Dadri (NCR) th 1-4	450	1548	2567
Gas thermal			
Dadri GT	1485	1350	2296
Auraiya GT	3189	3438	3578
Desu GT	807	786	576

Source. Aggregated from Central Electricity Authority 1992, 1993a, 1994

Industry

Sugar

Table 20.15. Sugar mills in the Yamuna sub-basin.

Name	Location	State	District	Capacity of crushed cane (t/d)
Up state sugar corp	Doiwala	UP	Dehradun	2500
Rai Bahadur Narain Singh Sugar Mills	Haridwar	UP	Haridwar	3500
Mahalakshmi	Haridwar	UP	Haridwar	3000
Gangeshwar	Deoband	UP	Sahranpur	10000
Kisan Co-operative	Sarsawa	UP	Sahranpur	2500
UP State Sugar Corporation	Sahranpur	UP	Sahranpur	2500
Kisan Sahakari Chini	Nanauta	UP	Sahranpur	2500
Mansurpur	Mansurpur	UP	Muzaffar Nagar	2500
Triveni Engineering Works	Khatauli	UP	Muzaffar Nagar	10000
UP State sugar	Muzaffar Nagar	UP	Muzaffar Nagar	1300
Upper Doab	Shamli	UP	Muzaffar Nagar	3810
Ganga Kisan Sahakari	Morna	UP	Muzaffar Nagar	2500
Titatwi Sugar	Titawi	UP	Muzaffar Nagar	3000
UP State sugar	Sakhoti-tanda	UP	Meerut	1500
Daurala	Daurala	UP	Meerut	6500
UP State sugar	Meerut	UP	Meerut	1219
UP State sugar	Mohiuddinpur	UP	Meerut	2500
Mawana	Mawana	UP	Meerut	8000
Bagpat	Bagpat	UP	Meerut	2500
Ramala Sahakari		UP	Meerut	1250
Modi Sugar Mills	Modinagar	UP	Ghaziabad	2500
Simbhaoli	Simbhaoli	UP	Ghaziabad	5000
UP State sugar	Panninagar	UP	Bulandshahr	1250
Kisan Sahakari	Anoopshahr	UP	Bulandshahr	2500
Agauta	Agauta	UP	Bulandshahr	2500
Saraswati	Yamunanagar	UP	Yamunanagar	8000
Panipat	Panipat	Haryana	Panipat	1800
Karnal Co-op	Karnal	Haryana	Karnal	1250
Haryana Co-op	Rohtak	Haryana	Rohtak	1750
Meham	Meham	Haryana	Rohtak	2500
Sonipat Co-op	Sonipat	Haryana	Sonipat	1250
Jind	Jind	Haryana	Jind	1250
Palwal	Palwal	Haryana	Faridabad	1250
Shahabad	Shahabad	Haryana	Kurukshetra	1250
Kaithal	Kaithal	Haryana	Kurukshetra	2500
Bhuna	Bhuna	Haryana	Hisar	2500
Rajasthan state Ganganagar	Ganganagar	Rajasthan	Ganganagar	1000

Source. Indian Sugar Mills Association. 1993. List of sugar mills in India, Bangladesh and Pakistan: 1991/92. New Delhi: Indian Sugar Mills Association. 158 pp.

Table 20.16. Urea plant in the Yamuna sub-basin

Plant	*Location*	*State*	*District*	*Production(' 000 tonnes)*
NFL	Panipat	Haryana	Panipat	455

Table 20.17. Super phosphate plants in the Yamuna sub-basin

Plant	*Location*	*State*	*District*	*Production(' 000 tonnes)*
Bharat chemicals & Fertilizers	Alwar	Rajasthan	Alwar	30 4
Hindustan Copper	Khetri	Rajasthan	Jhunjhunu	30.4
India Ceroils	Dharuhera	Haryana	Rewari	38.0
Jayshree chemicals	Pataudi	Haryana	Gurgaon	29.0
Oriental carbon and chemical	Dharuhera	Haryana	Rewari	44 1
Girraj Fertilizer and chemicals	Shikohabad	UP	Shikohabad	8.3
Natraj organics	Muzhafar nagar	UP	Muzhafar nagar	11 3
Neera chemical & Fertilizers	Ghaziabad	UP	Ghazhiabad	27 6
Vijay Fertilizers	Ghaziabad	UP	Ghazhiabad	23 4

Table 20.18. Cement plants in the Yamuna sub-basin

Name	*Location*	*State*	*District*	*Capacity (lakh t/y)*
ACC ltd(Bhupendra)	Surajpur	Haryana	Ambala	4 06
CCI ltd	Charkhi Dadri	Haryana	Bhiwani	1 72
CCI ltd	Rajban	HP	Sirmaur	2
Jaipur udyog ltd	Sawai madhopur	Rajasthan	Sawai madhopur	10

CHAPTER 21

Emission factors

An emission factor is defined as the ratio of the rate at which a pollutant is released into the atmosphere as a result of some activity, such as domestic fuel combustion or industrial production, to the rate of that activity. It is a composite of all the sub-processes comprising major processes, and does not take into account the matter of start-up/shut down or batch operations. The emission factors can be determined by detailed source testing involving many measurements or by engineering analysis of process material balances.

Emission factors depend on various parameters involved in the process. The important parameters among these are: (a) type of fuel and its composition. Because a particular fuel can have different composition, it is convenient to express the emission factors in terms of variable parameters. For example, the composition of coal varies with respect to ash (A) and sulphur (S) content. Hence, the emission factor of coal must be expressed in terms of these two parameters (A and S); (b) type of burner/furnace involved in the process; and (c) the process involved.

In this chapter, emission factors used in estimating emissions from the power sector, domestic sector (cooking in households), transport, and industry are presented. The pollutants considered in this study are carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NO_x), Sulphur oxide (SO_2), Lead (Pb) and total suspended particulates (TSP).

Transport

Automobile exhaust contributes invisible carbon monoxide, unburnt hydrocarbons, oxides of sulphur and nitrogen, lead and visible smoke. Data on emission factors are normally expressed in grammes of pollutant per kg of fuel used for various types of vehicles.

Table 21.1. Fuel efficiency of different vehicles

Mode	Fuel efficiency (km/l)
2 stroke 2 wheelers	44.4
4-stroke 2 wheelers	65.0
Petrol cars: pre-1984	9.4
Petrol cars: post-1984	14.2
Diesel cars	8.9
3 wheeler	20.4
Taxis petrol	9.4
Taxis diesel	8.9
Buses	3.3
Trucks	5.6
LCVs	10.0

Source. Dr Ranjan Bose, TERI, personal communication

Table 21.2: Emission factors (g/l)

Mode	CO	HC	NOx	SO2	TSP	Pb
2 stroke 2 wheelers	368.85	230.20	4.44	2.10	22 22	0.15
4 stroke 2 wheelers	539.50	46.80	25.35	2.10	5.20	0.15
Petrol cars: pre-1984	272.53	58.47	25.46	2.10	3.11	0 15
Petrol cars: post-1984	134.71	21.27	26.94	2.10	3 55	0.15
Diesel cars	9.75	2.48	12.40	8.26	5.32	0.00
3 wheelers	250.02	156.14	2.04	2.10	10.21	0.15
Buses	41.91	6.93	69.30	8.26	6.60	0 00
Trucks	70.49	11.66	116.55	8 26	11 10	0.00
LCVs	53.90	6.60	93.40	8.26	9.00	0 00

Source. Dr Ranjan Bose, TERI, personal communication

Domestic

Table 21.3. Emission factors for cookstoves (g/kg)

Pollutant	Dung	Coal/coke	Charcoal	Cooking gas	Wood	Kerosene	Crop residue
SPM	4.90	20 00	1 22		1 90	2 80	3 00
CO	31.00	17.00	10.88	0.02	17 00	41.00	27 00
SO2							
NOx				5.25			

Source. TERI 1992, p.8

Power

Table 21.4. Emission factors for power plants

Pollutant	*40% ash coal (g/kg)*	*Natural gas (g/m^3)*
SPM	320(1-eta)	0.08
SO2	16.60 S	0.0096
CO	1	0.272
HC	0.5	0.016
NOx	2.64	2.8

Note. eta=efficiency of electrostatic precipitator, S is sulphur content in coal

Source. TERI 1992 and Central Pollution Control Board, unpublished note

Table 21.5. Specific fuel consumption in power plants

Power plant	*Specific fuel consumption*
Steam	
Badarpur	0.84kg/kWh
I.P.Station	0.79kg/kWh
Rajghat	0.82kg/kWh
Faridabad	0 80kg/kWh
Panipat	0.83kg/kWh
Harduaganj B	1 02kg/kWh
Harduaganj A	1.00kg/kWh
Dadri (NCR)	0.72kg/kWh
Gas	
Dadri	$0.30m^3$/kWh
Auraiya	$0\ 30m^3$/kWh
Desu	$0.36m^3$/kWh

Source. Central Electricity Authority 1993b, pp.124,125 and Central Pollution Control Board, unpublished note

Industry

Table 21.6. Emission factors for different industrial products

Product	*Emission factor*	*Source of emission factor*
Sugar	20 kg/tonne	WHO 1982, p. 39
Urea	10 kg/tonne	WHO 1982
Normal superphosphate	0.76 kg/tonne	WHO 1993, p. 3–22
Cement	170 kg/tonne (Uncontrolled, 95% control assumed)	WHO 1982, p. 44

CHAPTER 22

Energy accounts

Transport

Table 22.1. Estimated consumption of fuels by the transport sector in Haryana (tonnes/year): 1992/93 to 1995/96

	1992/93		1993/94		1994/95		1995/96	
District	*Petrol*	*Diesel*	*Petrol*	*Diesel*	*Petrol*	*Diesel)*	*Petrol*	*Diesel*
Ambala	12,542	51,248	14,792	35,072	15,778	38,927	16,479	47,422
Yamunanagar	5,990	19,923	6,880	14,715	7,713	15,930	8,169	19,271
Kurukshetra	4,029	10,836	4,348	9,123	4,686	9,503	4,902	11,359
Kaithal	2,769	24,096	2,693	17,321	2,852	18,897	2,957	22,924
Karnal	6,727	72,545	7,498	47,690	8,010	53,574	8,366	65,542
Panipat	4,734	22,512	5,077	16,789	5,453	18,116	5,699	21,898
Sonipat	5,314	75,622	4,863	52,133	5,360	57,634	5,588	70,196
Rohtak	5,312	14,272	5,351	13,068	5,678	13,310	5,865	15,788
Faridabad	30,220	59,502	31,065	59,359	33,762	59,170	35,103	69,667
Gurgaon	12,668	50,508	13,065	40,622	14,954	42,860	15,775	51,445
Rewari	1,700	21,286	1,783	14,211	1,905	15,879	1,988	19,399
Mahendragarh	1,043	12,501	1,003	8,648	1,069	9,551	1,107	11,629
Bhiwani	3,071	38,030	2,841	26,541	3,063	29,229	3,172	35,557
Jind	2,098	22,944	2,112	15,780	2,324	17,461	2,434	21,271
Hissar	10,616	58,661	11,671	41,841	12,927	45,777	13,619	55,566
Sirsa	7,166	18,341	7,958	14,772	8,465	15,609	8,778	18,723

Table 22.2. Estimated consumption of fuels by the transport sector in Himachal (tonnes/year): 1992/93 to 1995/96

	1992/93		1993/94		1994/95		1995/96	
District	*Petrol*	*Diesel*	*Petrol*	*Diesel*	*Petrol*	*Diesel)*	*Petrol*	*Diesel*
Shimla	1,509	14,516	1,607	14,779	1,520	17,388	2,007	18,291
Sirmaur	639	10,557	696	10,911	692	12,456	885	13,332
Solan	1,445	22,225	1,550	23,026	1,522	26,149	1,935	28,079

Table 22.3. Estimated consumption of fuels by the transport sector in Rajasthan (tonnes/year): 1992/93 to 1995/96

	1992/93		1993/94		1994/95		1995/96	
District	*Petrol*	*Diesel*	*Petrol*	*Diesel*	*Petrol*	*Diesel)*	*Petrol*	*Diesel*
Alwar	4,911	32,769	5,382	35,913	5,888	39,288	6,462	43,117
Bharatpur	2,768	25,507	3,033	27,954	3,318	30,580	3,641	33,560
Jaipur	45,109	249,225	49,437	273,136	54,083	298,802	59,353	327,919
Jhunjhunu	2,435	22,887	2,668	25,083	2,919	27,440	3,203	30,114
S. Madhopur	1,307	15,174	1,432	16,630	1,567	18,913	1,720	19,966
Sikar	3,006	21,884	3,295	23,490	3,604	26,189	3,955	28,741
Dhaulpur	433	4,570	474	5,009	519	5,479	569	6,013
Dausa	215	613	235	671	257	734	283	806
Churu	3,181	18,272	3,486	20,025	3,814	21,907	4,185	24,041
Ganganagar	8,535	50,125	9,330	54,934	10,233	60,096	11,230	65,952

Table 22.4. Estimated consumption of fuels by the transport sector in Delhi (tonnes/year): 1992/93 to 1994/95

Fuel	*1992/93*	*1993/94*	*1994/95*
Diesel	439,026	500,345	527,235
Petrol	363,000	375,000	408,000

Table 22.5: Estimated consumption of fuels by the transport sector in Uttar Pradesh (tonnes/year): 1992/93 to 1995/96

	1992/93		1993/94		1994/95		1995/96	
District	*Petrol*	*Diesel*	*Petrol*	*Diesel*	*Petrol*	*Diesel*	*Petrol*	*Diesel*
Agra	20,563	36,267	22,556	39,781	23,412	41,291	24,327	42,904
Aligarh	3,627	27,794	3,978	30,487	4,129	31,645	4,291	32,881
Bulandshahr	2,357	33,697	2,585	36,962	2,683	38,366	2,788	39,864
Dehradun	15,566	36,189	17,074	39,696	17,723	41,203	18,415	42,812
Etawah	2,008	10,775	2,203	11,819	2,286	12,268	2,375	12,747
Ghaziabad	4,765	29,892	5,227	32,788	5,425	34,034	5,637	35,363
Mathura	3,884	14,802	4,260	16,236	4,422	16,853	4,594	17,511
Meerut	9,997	62,093	10,965	68,109	11,382	70,696	11,826	73,457
Muzaffar Nagar	1,535	15,378	1,684	16,868	1,748	17,508	1,816	18,192
Sahranpur	3,481	21,030	3,818	23,068	3,963	23,944	4,118	24,879
Haridwar	4,081	8,001	4,477	8,777	4,647	9,110	4,828	9,466
Firozabad	2,010	5,183	2,204	5,685	2,288	5,901	2,377	6,132
Etah	1,522	14,407	1,669	15,803	1,733	16,403	1,800	

Domestic

Table 22.6. Estimated cooking fuel consumption in the domestic sector (tonnes/year): 1992/93

District	*Rural or urban*	*Dung*	*Coal/coke*	*Charcoal*	*Cooking gas*	*Wood*	*Kerosene*	*Others*
Ambala	Rural	209,080	221	617	968	120,358	1,854	2,077
Ambala	Urban	20,451	1,033	1,006	9,279	20,263	4,220	1,622
Kurukshetra	Rural	260,536	46	214	343	32,121	396	1,307
Kurukshetra	Urban	17,145	263	198	2,823	13,510	1,770	546
Karnal	Rural	304,309	103	480	487	63,569	350	1,357
Karnal	Urban	29,396	416	403	4,514	20,657	2,597	609
Jind	Rural	192,171	107	531	92	187,752	148	1,397
Jind	Urban	25,440	1,530	540	1,931	30,429	875	313
Sonipat	Rural	124,633	92	253	547	132,355	508	1,500
Sonipat	Urban	27,482	384	711	3,109	17,014	1,321	274
Panipat	Rural	197,859	130	188	416	107,962	535	1,095
Panipat	Urban	22,106	747	730	3,783	19,876	3,065	1,012
Rohtak	Rural	377,709	209	363	587	310,364	166	5,021
Rohtak	Urban	66,068	674	926	7,140	37,649	2,040	1,040
Faridabad	Rural	115,717	81	236	196	212,900	207	1,194
Faridabad	Urban	77,334	1,017	1,247	9,356	75,990	13,228	3,042
Gurgaon	Rural	250,301	329	483	706	185,099	639	2,494
Gurgaon	Urban	25,403	547	426	4,520	25,672	1,610	843
Mahendragarh	Rural	23,849	32	185	72	202,312	52	2,538
Mahendragarh	Urban	2,758	7	119	936	26,464	347	98
Bhiwani	Rural	113,659	63	198	185	281,092	159	2,210
Bhiwani	Urban	28,153	382	743	2,289	35,932	1,510	689
Hissar	Rural	66,198	194	663	371	487,685	409	1,949
Hissar	Urban	22,929	976	1,070	5,561	78,192	3,027	796
Sirsa	Rural	11,988	86	26	259	249,215	203	1,119
Sirsa	Urban	4,280	234	294	2,184	47,510	2,135	376
Rewari	Rural	54,905	430	101	181	151,020	436	5,332
Rewari	Urban	7,661	686	385	1,204	16,961	966	227
Kaithal	Rural	331,711	224	281	144	77,242	242	1,839
Kaithal	Urban	29,916	499	426	1,073	15,277	1,308	232
Yamunanagar	Rural	169,620	160	94	372	98,211	560	1,460
Yamunanagar	Urban	20,681	290	661	4,247	36,978	3,817	736
Shimla	Rural	139	39	320	296	159,205	1,586	251
Shimla	Urban	76	149	64	2,233	3,572	3,499	326
Sirmaur	Rural	290	18	256	136	114,317	749	148
Sirmaur	Urban	43	7	33	634	3,780	822	166
Solan	Rural	260	44	257	340	102,501	1,494	274
Solan	Urban	49	43	21	878	1,881	1,210	100
Alwar	Rural	328,776	191	732	487	829,237	1,090	25,238
Alwar	Urban	14,146	124	795	3,899	62,634	4,552	839
Bharatpur	Rural	504,420	77	510	199	439,880	208	2,186
Bharatpur	Urban	33,162	548	1,051	2,930	92,892	1,121	705
Jaipur	Rural	132,582	719	1,700	619	1,418,749	1,324	6,398
Jaipur	Urban	25,491	2,719	8,172	23,095	339,401	31,293	3,093

Table 22.6 continued. Estimated cooking fuel consumption in the domestic sector (tonnes/year): 1992/93

District	*Rural or urban*	*Dung*	*Coal/coke*	*Charcoal*	*Cooking gas*	*Wood*	*Kerosene*	*Others*
Jhunjhunu	Rural	1,734	17	350	221	459,621	183	2,769
Jhunjhunu	Urban	646	152	888	2,368	121,036	1,283	1,190
S. Madhopur	Rural	542,642	421	1,260	237	590,550	451	4,745
S. Madhopur	Urban	11,706	1,114	1,793	2,043	93,923	1,326	1,403
Sikar	Rural	6,621	85	462	234	764,700	228	1,141
Sikar	Urban	1,842	271	2,211	2,642	147,348	1,301	373
Dhaulpur	Rural	94,396	108	172	93	276,412	86	2,109
Dhaulpur	Urban	5,534	200	610	808	46,729	398	462
Churu	Rural	19,994	30	234	32	397,022	159	949
Churu	Urban	4,511	459	1,402	2,305	178,965	1,842	859
Ganganagar	Rural	12,403	83	151	155	750,107	259	1,440
Ganganagar	Urban	7,063	1,180	1,018	3,781	173,516	6,212	1,064
Agra	Rural	412,929	269	772	213	512,287	61	6,283
Agra	Urban	81,533	15,322	7,370	12,560	245,695	4,002	5,481
Aligarh	Rural	1,093,556	567	692	313	532,357	118	5,469
Aligarh	Urban	115,506	7,386	4,166	6,443	206,045	2,406	2,746
Bulandshahr	Rural	1,368,957	1,297	506	243	288,697	228	8,219
Bulandshahr	Urban	101,960	4,122	2,375	4,550	148,797	1,349	2,102
Dehradun	Rural	1,334	54	286	2,003	132,459	2,351	677
Dehradun	Urban	2,049	451	465	10,460	36,358	9,620	1,867
Etawah	Rural	202,553	118	261	295	638,122	219	41,682
Etawah	Urban	2,913	395	744	1,932	133,945	1,003	1,093
Ghaziabad	Rural	1,056,336	574	326	775	76,404	1,416	4,978
Ghaziabad	Urban	260,771	11,541	3,461	16,618	97,050	13,276	3,656
Mathura	Rural	350,284	4,120	563	626	444,733	212	9,721
Mathura	Urban	39,230	3,776	1,884	3,660	124,225	2,166	2,070
Meerut	Rural	1,685,534	1,034	511	708	82,179	242	5,638
Meerut	Urban	365,434	10,389	2,896	15,081	125,368	7,607	4,083
Muzaffar Nagar	Rural	164,685	53	46	43	9,122	36	787
Muzaffar Nagar	Urban	185,298	2,920	1,874	6,180	122,055	2,927	2,614
Sahranpur	Rural	771,504	734	675	408	353,421	302	6,914
Sahranpur	Urban	40,976	4,341	1,799	7,132	134,326	3,180	3,000
Uttarkashi	Rural	68,562	77	62	36	43,188	65	653
Uttarkashi	Urban	1,493	168	60	165	3,686	160	67
Haridwar	Rural	238,364	153	418	460	208,280	557	3,638
Haridwar	Urban	9,810	2,137	725	6,207	55,240	2,830	1,543
Firozabad	Rural	278,857	647	303	146	351,382	36	5,880
Firozabad	Urban	12,364	14,534	2,584	3,304	104,826	582	1,304
Tehri Garhwal	Rural	1,817	80	233	342	179,396	1,172	2,123
Tehri Garhwal	Urban	51	19	8	470	1,351	988	412
Etah	Rural	751,436	215	566	113	443,904	60	5,802
Etah	Urban	20,920	2,493	821	2,436	137,351	375	998
Mainpuri	Rural	538,062	113	282	123	230,668	36	3,148
Mainpuri	Urban	7,515	253	526	1,411	59,050	516	737
Delhi	Rural	162,955	672	865	4,388	56,203	16,169	1,002
Delhi	Urban	212,345	14,644	4,720	156,283	162,838	222,647	12,733

Table 22.7. Estimated cooking fuel consumption in the domestic sector (tonnes/year): 1993/94

District	Rural or urban	*Dung*	*Coal/coke*	*Charcoal*	*Cooking gas*	*Wood*	*Kerosene*	*Others*
Ambala	Rural	212917	225	628	986	122567	1888	2115
Ambala	Urban	20826	1052	1024	9449	20635	4297	1652
Kurukshetra	Rural	265317	46	217	349	32710	404	1331
Kurukshetra	Urban	17460	268	202	2875	13758	1803	557
Karnal	Rural	309893	105	489	495	64735	356	1382
Karnal	Urban	29936	423	411	4596	21036	2644	621
Jind	Rural	195697	108	541	94	191197	151	1422
Jind	Urban	25906	1559	550	1967	30987	891	318
Sonipat	Rural	126920	94	257	557	134784	518	1528
Sonipat	Urban	27986	391	724	3166	17326	1345	279
Panipat	Rural	201489	132	192	424	109943	545	1115
Panipat	Urban	22512	761	743	3852	20241	3121	1030
Rohtak	Rural	384639	213	370	597	316059	169	5113
Rohtak	Urban	67280	686	943	7271	38339	2078	1059
Faridabad	Rural	117840	83	240	199	216807	211	1215
Faridabad	Urban	78753	1036	1270	9528	77384	13471	3098
Gurgaon	Rural	254894	335	492	719	188495	651	2539
Gurgaon	Urban	25869	557	434	4603	26143	1640	858
Mahendragarh	Rural	24286	32	189	74	206024	53	2584
Mahendragarh	Urban	2809	7	121	954	26949	353	100
Bhiwani	Rural	115744	64	201	188	286249	162	2251
Bhiwani	Urban	28669	389	757	2331	36591	1538	702
Hissar	Rural	67412	198	676	378	496633	416	1984
Hissar	Urban	23350	994	1089	5663	79626	3082	810
Sirsa	Rural	12208	87	26	263	253788	207	1140
Sirsa	Urban	4359	238	300	2224	48381	2174	383
Rewari	Rural	55912	438	103	184	153791	444	5429
Rewari	Urban	7801	699	392	1226	17272	984	232
Kaithal	Rural	337798	228	286	147	78660	246	1873
Kaithal	Urban	30465	508	434	1092	15558	1332	237
Yamunanagar	Rural	172732	163	96	379	100013	571	1486
Yamunanagar	Urban	21060	296	673	4325	37656	3888	750
Shimla	Rural	141	40	326	301	162126	1616	255
Shimla	Urban	78	152	65	2274	3638	3563	332
Sirmaur	Rural	295	18	261	139	116414	763	151
Sirmaur	Urban	44	7	33	645	3849	837	169
Solan	Rural	265	45	262	347	104382	1521	279
Solan	Urban	50	44	22	894	1916	1232	102
Alwar	Rural	334809	195	745	496	844452	1110	25701
Alwar	Urban	14406	127	809	3971	63783	4636	855
Bharatpur	Rural	513675	79	520	203	447951	212	2227
Bharatpur	Urban	33771	558	1070	2984	94596	1142	718
Jaipur	Rural	135015	732	1731	630	1444781	1349	6516
Jaipur	Urban	25959	2769	8322	23518	345629	31868	3150

Table 22.7 continued. Estimated domestic cooking fuel consumption (tonnes/year): 1993/94

District	Rural or urban	Dung	Coal/coke	Charcoal	Cooking gas	Wood	Kerosene	Others
Jhunjhunu	Rural	1766	17	357	225	468054	186	2820
Jhunjhunu	Urban	658	154	905	2412	123257	1307	1212
S. Madhopur	Rural	552599	429	1283	242	601386	459	4832
S. Madhopur	Urban	11921	1135	1826	2080	95646	1350	1429
Sikar	Rural	6743	86	470	238	778732	232	1162
Sikar	Urban	1876	276	2251	2690	150051	1325	380
Dhaulpur	Rural	96129	110	176	94	281484	87	2148
Dhaulpur	Urban	5635	204	621	823	47587	406	470
Churu	Rural	20361	30	239	32	404307	162	967
Churu	Urban	4593	468	1428	2348	182248	1876	875
Ganganagar	Rural	12631	84	154	158	763870	264	1466
Ganganagar	Urban	7192	1201	1037	3850	176699	6326	1083
Agra	Rural	420506	274	787	217	521687	62	6399
Agra	Urban	83029	15603	7505	12790	250203	4075	5582
Aligarh	Rural	1113621	578	704	318	542125	120	5570
Aligarh	Urban	117625	7522	4242	6562	209826	2450	2796
Bulandshahr	Rural	1394075	1321	515	248	293994	232	8370
Bulandshahr	Urban	103831	4198	2419	4634	151527	1374	2140
Dehradun	Rural	1358	55	291	2040	134889	2394	689
Dehradun	Urban	2087	459	474	10652	37026	9797	1902
Etawah	Rural	206270	120	266	300	649831	223	42447
Etawah	Urban	2967	403	757	1968	136402	1021	1113
Ghaziabad	Rural	1075718	584	332	789	77806	1442	5069
Ghaziabad	Urban	265556	11752	3524	16923	98830	13520	3723
Mathura	Rural	356711	4195	573	638	452893	216	9899
Mathura	Urban	39950	3845	1919	3727	126504	2206	2108
Meerut	Rural	1716461	1053	521	721	83687	247	5741
Meerut	Urban	372139	10580	2949	15358	127669	7747	4158
Muzaffar Nagar	Rural	167707	54	47	44	9289	37	802
Muzaffar Nagar	Urban	188697	2974	1908	6293	124294	2981	2662
Sahranpur	Rural	785660	747	687	416	359905	307	7041
Sahranpur	Urban	41728	4420	1832	7263	136790	3239	3055
Uttarkashi	Rural	69820	78	63	36	43980	66	665
Uttarkashi	Urban	1521	171	61	169	3753	163	68
Haridwar	Rural	242737	156	426	468	212102	567	3705
Haridwar	Urban	9990	2176	738	6321	56254	2882	1571
Firozabad	Rural	283974	659	308	149	357829	37	5988
Firozabad	Urban	12591	14801	2632	3365	106749	592	1328
Tehri Garhwal	Rural	1851	81	237	349	182688	1193	2162
Tehri Garhwal	Urban	52	20	8	478	1376	1006	420
Etah	Rural	765224	219	576	115	452049	61	5909
Etah	Urban	21304	2538	836	2481	139871	382	1016
Mainpuri	Rural	547934	115	287	125	234900	37	3206
Mainpuri	Urban	7653	258	536	1437	60133	525	751
Delhi	Rural	165945	684	881	4468	57234	16465	1020
Delhi	Urban	216241	14913	4807	159151	165826	226732	12967

Table 22.8. Estimated domestic cooking fuel consumption (tonnes/year): 1994/95

District	Rural or urban	Dung	Coal/coke	Charcoal	Cooking gas	Wood	Kerosene	Others
Ambala	Rural	216753	229	640	1003	124775	1922	2153
Ambala	Urban	21201	1071	1043	9619	21007	4375	1681
Kurukshetra	Rural	270097	47	221	356	33300	411	1355
Kurukshetra	Urban	17774	273	206	2927	14006	1835	567
Karnal	Rural	315476	107	498	504	65901	363	1407
Karnal	Urban	30475	431	418	4679	21415	2692	632
Jind	Rural	199223	110	550	96	194642	154	1448
Jind	Urban	26373	1587	560	2002	31546	907	324
Sonipat	Rural	129207	96	262	567	137212	527	1556
Sonipat	Urban	28491	398	737	3223	17639	1369	285
Panipat	Rural	205120	134	195	431	111924	555	1135
Panipat	Urban	22918	775	756	3922	20606	3177	1049
Rohtak	Rural	391569	217	377	608	321753	172	5206
Rohtak	Urban	68492	699	960	7402	39030	2115	1078
Faridabad	Rural	119963	84	244	203	220713	214	1237
Faridabad	Urban	80172	1055	1293	9699	78778	13714	3153
Gurgaon	Rural	259486	341	501	732	191892	663	2585
Gurgaon	Urban	26335	567	442	4685	26614	1670	874
Mahendragarh	Rural	24724	33	192	75	209736	54	2631
Mahendragarh	Urban	2859	7	123	971	27435	360	101
Bhiwani	Rural	117830	65	205	191	291407	165	2292
Bhiwani	Urban	29186	396	770	2373	37250	1565	715
Hissar	Rural	68627	201	688	385	505581	424	2020
Hissar	Urban	23771	1012	1109	5765	81061	3138	825
Sirsa	Rural	12428	89	27	268	258361	211	1160
Sirsa	Urban	4437	243	305	2264	49253	2213	390
Rewari	Rural	56920	446	105	188	156562	452	5527
Rewari	Urban	7942	711	399	1248	17584	1001	236
Kaithal	Rural	343884	233	291	150	80077	251	1906
Kaithal	Urban	31014	517	441	1112	15838	1356	241
Yamunanagar	Rural	175844	166	98	386	101815	581	1513
Yamunanagar	Urban	21439	301	686	4403	38335	3958	763
Shimla	Rural	144	40	331	307	165047	1645	260
Shimla	Urban	79	155	66	2315	3703	3627	338
Sirmaur	Rural	300	19	266	141	118512	777	154
Sirmaur	Urban	44	7	34	657	3918	852	172
Solan	Rural	270	46	267	353	106263	1548	284
Solan	Urban	51	45	22	910	1950	1254	104
Alwar	Rural	340841	198	759	505	859668	1130	26164
Alwar	Urban	14665	129	824	4042	64933	4719	870
Bharatpur	Rural	522931	80	529	206	456022	216	2267
Bharatpur	Urban	34379	568	1090	3038	96301	1162	731
Jaipur	Rural	137447	745	1762	642	1470813	1373	6633
Jaipur	Urban	26427	2819	8472	23942	351856	32442	3207

Table 22.8 continued. Estimated domestic cooking fuel consumption (tonnes/year): 1994/95

District	Rural or urban	*Dung*	*Coal/coke*	*Charcoal*	*Cooking gas*	*Wood*	*Kerosene*	*Others*
Jhunjhunu	Rural	1798	18	363	229	476487	189	2871
Jhunjhunu	Urban	670	157	921	2455	125477	1330	1234
S. Madhopur	Rural	562555	436	1307	246	612222	467	4919
S. Madhopur	Urban	12136	1155	1859	2118	97370	1374	1455
Sikar	Rural	6864	88	479	242	792763	236	1183
Sikar	Urban	1910	281	2292	2739	152755	1349	387
Dhaulpur	Rural	97861	112	179	96	286556	89	2186
Dhaulpur	Urban	5737	208	633	838	48444	413	479
Churu	Rural	20727	31	243	33	411592	165	984
Churu	Urban	4676	476	1454	2390	185532	1910	891
Ganganagar	Rural	12858	86	157	160	777634	269	1493
Ganganagar	Urban	7322	1223	1055	3919	179883	6440	1103
Agra	Rural	428083	279	801	221	531086	63	6514
Agra	Urban	84525	15885	7640	13021	254711	4149	5682
Aligarh	Rural	1133686	588	717	324	551893	122	5670
Aligarh	Urban	119745	7657	4318	6680	213606	2494	2847
Bulandshahr	Rural	1419194	1345	525	252	299292	236	8521
Bulandshahr	Urban	105702	4273	2462	4717	154258	1398	2179
Dehradun	Rural	1383	56	296	2077	137319	2438	702
Dehradun	Urban	2125	467	482	10844	37693	9973	1936
Etawah	Rural	209986	122	271	306	661540	227	43212
Etawah	Urban	3020	410	771	2003	138860	1039	1133
Ghaziabad	Rural	1095100	595	338	803	79207	1468	5161
Ghaziabad	Urban	270340	11964	3588	17228	100611	13763	3790
Mathura	Rural	363138	4271	583	649	461053	220	10078
Mathura	Urban	40670	3914	1953	3794	128783	2246	2146
Meerut	Rural	1747388	1072	530	734	85195	251	5845
Meerut	Urban	378844	10770	3002	15634	129969	7886	4233
Muzaffar Nagar	Rural	170728	55	47	44	9457	38	816
Muzaffar Nagar	Urban	192097	3027	1943	6406	126534	3035	2710
Sahranpur	Rural	799816	761	700	423	366390	313	7168
Sahranpur	Urban	42480	4500	1865	7393	139255	3297	3110
Uttarkashi	Rural	71078	79	65	37	44773	67	677
Uttarkashi	Urban	1548	174	62	172	3821	166	69
Haridwar	Rural	247111	159	433	477	215924	577	3772
Haridwar	Urban	10170	2215	752	6435	57267	2933	1600
Firozabad	Rural	289090	670	314	152	364276	37	6096
Firozabad	Urban	12818	15067	2679	3425	108673	603	1352
Tehri Garhwal	Rural	1884	83	241	355	185979	1215	2201
Tehri Garhwal	Urban	53	20	8	487	1401	1024	427
Etah	Rural	779012	223	587	117	460194	62	6015
Etah	Urban	21688	2584	852	2525	142392	389	1034
Mainpuri	Rural	557807	117	292	128	239133	38	3264
Mainpuri	Urban	7791	263	545	1463	61217	535	764
Delhi	Rural	168935	696	897	4549	58265	16762	1039
Delhi	Urban	220138	15182	4893	162019	168814	230818	13200

Table 22.9. Estimated domestic cooking fuel consumption (tonnes/year): 1995/96

District	Rural or urban	Dung	Coal/coke	Charcoal	Cooking gas	Wood	Kerosene	Others
Ambala	Rural	220,829	234	652	1,022	127,122	1,958	2,193
Ambala	Urban	21,600	1,091	1,062	9,800	21,402	4,457	1,713
Kurukshetra	Rural	275,177	48	226	362	33,926	419	1,380
Kurukshetra	Urban	18,109	278	209	2,982	14,269	1,870	577
Karnal	Rural	321,409	109	507	514	67,141	369	1,433
Karnal	Urban	31,048	439	426	4,767	21,817	2,743	644
Jind	Rural	202,969	112	561	98	198,302	157	1,475
Jind	Urban	26,869	1,616	571	2,040	32,139	924	330
Sonipat	Rural	131,637	98	267	578	139,792	537	1,585
Sonipat	Urban	29,027	405	751	3,283	17,970	1,395	290
Panipat	Rural	208,977	137	199	439	114,028	565	1,156
Panipat	Urban	23,349	789	771	3,995	20,993	3,237	1,069
Rohtak	Rural	398,933	221	384	619	327,804	175	5,303
Rohtak	Urban	69,780	712	978	7,541	39,764	2,155	1,098
Faridabad	Rural	122,219	86	249	207	224,864	218	1,261
Faridabad	Urban	81,680	1,075	1,317	9,882	80,260	13,972	3,213
Gurgaon	Rural	264,366	348	510	745	195,500	675	2,634
Gurgaon	Urban	26,830	578	450	4,774	27,115	1,701	890
Mahendragarh	Rural	25,189	34	196	76	213,680	55	2,681
Mahendragarh	Urban	2,913	7	126	989	27,951	366	103
Bhiwani	Rural	120,046	67	209	195	296,887	168	2,335
Bhiwani	Urban	29,734	403	785	2,418	37,951	1,595	728
Hissar	Rural	69,918	205	701	392	515,089	432	2,058
Hissar	Urban	24,218	1,031	1,130	5,874	82,586	3,197	840
Sirsa	Rural	12,661	90	27	273	263,219	215	1,182
Sirsa	Urban	4,521	247	311	2,307	50,179	2,254	397
Rewari	Rural	57,990	454	107	191	159,506	460	5,631
Rewari	Urban	8,091	725	407	1,272	17,914	1,020	240
Kaithal	Rural	350,351	237	297	152	81,583	256	1,942
Kaithal	Urban	31,597	527	450	1,133	16,136	1,382	246
Yamunanagar	Rural	179,151	169	100	393	103,730	592	1,542
Yamunanagar	Urban	21,843	307	698	4,486	39,056	4,032	778
Shimla	Rural	147	41	338	313	168,151	1,676	265
Shimla	Urban	81	158	67	2,358	3,773	3,695	344
Sirmaur	Rural	306	19	271	144	120,741	791	157
Sirmaur	Urban	45	7	35	669	3,992	868	175
Solan	Rural	275	47	272	360	108,261	1,577	289
Solan	Urban	52	46	23	927	1,987	1,278	106
Alwar	Rural	347,251	202	773	515	875,834	1,151	26,656
Alwar	Urban	14,941	131	839	4,118	66,154	4,808	887
Bharatpur	Rural	532,765	82	539	210	464,598	220	2,309
Bharatpur	Urban	35,026	579	1,110	3,095	98,111	1,184	744
Jaipur	Rural	140,032	759	1,795	654	1,498,472	1,399	6,758
Jaipur	Urban	26,924	2,872	8,631	24,392	358,473	33,052	3,267

Table 22.9 continued. Estimated domestic cooking fuel consumption (tonnes/year): 1995/96

District	*Rural or urban*	*Dung*	*Coal/coke*	*Charcoal*	*Cooking gas*	*Wood*	*Kerosene*	*Others*
Jhunjhunu	Rural	1,832	18	370	233	485,448	193	2,925
Jhunjhunu	Urban	682	160	938	2,501	127,837	1,355	1,257
S. Madhopur	Rural	573,134	445	1,331	251	623,735	476	5,011
S. Madhopur	Urban	12,364	1,177	1,894	2,157	99,201	1,400	1,482
Sikar	Rural	6,993	89	488	247	807,671	241	1,205
Sikar	Urban	1,946	286	2,335	2,790	155,628	1,374	394
Dhaulpur	Rural	99,701	114	182	98	291,945	90	2,227
Dhaulpur	Urban	5,845	211	644	854	49,355	421	488
Churu	Rural	21,117	32	248	33	419,332	168	1,003
Churu	Urban	4,764	485	1,481	2,435	189,021	1,946	908
Ganganagar	Rural	13,100	88	160	163	792,257	274	1,521
Ganganagar	Urban	7,459	1,246	1,075	3,993	183,266	6,561	1,124
Agra	Rural	436,133	284	816	225	541,074	64	6,636
Agra	Urban	86,115	16,183	7,784	13,266	259,501	4,227	5,789
Aligarh	Rural	1,155,006	599	731	330	562,272	125	5,777
Aligarh	Urban	121,997	7,801	4,400	6,805	217,623	2,541	2,900
Bulandshahr	Rural	1,445,882	1,370	535	257	304,920	241	8,681
Bulandshahr	Urban	107,690	4,354	2,508	4,806	157,158	1,425	2,220
Dehradun	Rural	1,409	57	302	2,116	139,902	2,483	715
Dehradun	Urban	2,165	476	491	11,048	38,401	10,161	1,972
Etawah	Rural	213,935	124	276	312	673,980	231	44,024
Etawah	Urban	3,077	418	786	2,041	141,471	1,059	1,155
Ghaziabad	Rural	1,115,694	606	345	818	80,697	1,495	5,258
Ghaziabad	Urban	275,424	12,189	3,655	17,552	102,503	14,022	3,862
Mathura	Rural	369,967	4,351	594	662	469,724	224	10,267
Mathura	Urban	41,435	3,988	1,990	3,866	131,205	2,288	2,187
Meerut	Rural	1,780,248	1,092	540	748	86,797	256	5,955
Meerut	Urban	385,969	10,973	3,059	15,929	132,413	8,035	4,313
Muzaffar Nagar	Rural	173,939	56	48	45	9,635	39	832
Muzaffar Nagar	Urban	195,710	3,084	1,979	6,527	128,913	3,092	2,761
Sahranpur	Rural	814,857	775	713	431	373,280	319	7,303
Sahranpur	Urban	43,278	4,585	1,900	7,533	141,874	3,359	3,168
Uttarkashi	Rural	72,415	81	66	38	45,615	68	690
Uttarkashi	Urban	1,577	177	64	175	3,893	169	70
Haridwar	Rural	251,758	162	441	486	219,984	588	3,843
Haridwar	Urban	10,361	2,257	766	6,556	58,344	2,989	1,630
Firozabad	Rural	294,527	683	320	154	371,127	38	6,211
Firozabad	Urban	13,059	15,351	2,730	3,490	110,716	614	1,377
Tehri Garhwal	Rural	1,920	84	246	362	189,477	1,238	2,242
Tehri Garhwal	Urban	54	20	8	496	1,427	1,043	435
Etah	Rural	793,661	227	598	119	468,848	63	6,128
Etah	Urban	22,096	2,633	868	2,573	145,069	396	1,054
Mainpuri	Rural	568,297	119	298	130	243,630	38	3,325
Mainpuri	Urban	7,937	268	556	1,490	62,368	545	779
Delhi	Rural	172,112	709	914	4,634	59,361	17,077	1,058
Delhi	Urban	224,277	15,467	4,985	165,065	171,989	235,158	13,448

Power

Table 22.10. Estimated fuel consumption in power plants in the Yamuna sub-basin: 1992/93 to 1994/95

[Coal consumption in thousand tonnes, natural gas consumption in million m^3]

Power plant	*1992/93*	*1993/94*	*1994/95*
Steam			
Badarpur	3993	3878	3929
I.P Station	1131	939	912
Rajghat	478	524	705
Faridabad	715	593	629
Panipat	2214	1780	1999
Harduaganj B	958	1031	767
Harduaganj A	0	0	0
Dadri (NCR)	324	1115	1848
Gas			
Dadri	446	405	689
Auraiya	957	1031	1073
Desu	291	283	208

Emission accounts

Transport

Table 23.1. Emissions (kg/year) in Haryana in transport sector: 1992/93

District	*Emissions*	District	*Emissions*	District	*Emissions*
Ambala		**Panipat**		**Rewari**	
CO	7,840,438	CO	3,278,149	CO	1,867,294
HC	2,904,841	HC	1,264,455	HC	580,490
NOx	4,861,661	NOx	2,241,443	NOx	1,923,856
SO2	549,923	SO2	239,265	SO2	217,993
TSP	664,318	TSP	300,681	TSP	216,142
Pb	2,658	Pb	1,003	Pb	360
Yamunanagar		**Sonipat**		**Mahendragarh**	
CO	3,547,202	CO	6,249,128	CO	1,115,159
HC	1,481,801	HC	1,828,829	HC	340,725
NOx	1,984,446	NOx	6,980,332	NOx	1,160,143
SO2	217,095	SO2	772,280	SO2	128,151
TSP	291,125	TSP	753,832	TSP	129,054
Pb	1,270	Pb	1,126	Pb	221
Kurukshetra		**Rohtak**		**Bhiwani**	
CO	2,345,366	CO	2,995,609	CO	3,310,393
HC	989,428	HC	1,141,205	HC	977,436
NOx	1,201,663	NOx	1,699,913	NOx	3,551,376
SO2	120,366	SO2	158,548	SO2	389,559
TSP	186,742	TSP	239,370	TSP	387,720
Pb	854	Pb	1,126	Pb	651
Kaithal		**Faridabad**		**Jind**	
CO	2,521,627	CO	15,451,877	CO	2,094,328
HC	850,426	HC	6,064,538	HC	656,365
NOx	2,307,233	NOx	7,672,930	NOx	2,120,883
SO2	249,278	SO2	685,008	SO2	235,756
TSP	271,890	TSP	1,134,415	TSP	237,436
Pb	587	Pb	6,405	Pb	445
Karnal		**Gurgaon**		**Hissar**	
CO	6,641,497	CO	7,644,880	CO	7,542,943
HC	2,067,177	HC	2,843,665	HC	2,802,449
NOx	6,508,685	NOx	5,337,459	NOx	5,629,243
SO2	745,696	SO2	542,894	SO2	618,361
TSP	738,872	TSP	673,016	TSP	715,325
Pb	1,426	Pb	2,685	Pb	2,250
Sirsa					
CO	3,809,065				
HC	1,394,865				
NOx	2,008,835				
SO2	204,765				
TSP	285,451				
Pb	1,519				

Table 23.2 Estimated emissions (kg/year) in Haryana in transport sector: 1993/94

District	*Emissions*	District	*Emissions*	District	*Emissions*
Ambala		**Panipat**		**Rewari**	
CO	8,011,145	CO	3,202,064	CO	1,574,643
HC	3,213,482	HC	1,305,408	HC	548,011
NOx	3,567,631	NOx	1,781,263	NOx	1,337,156
SO2	394,711	SO2	183,011	SO2	147,451
TSP	582,255	TSP	268,038	TSP	164,136
Pb	3,129	Pb	1,074	Pb	377
Yamunanagar		**Sonipat**		**Mahendragarh**	
CO	3,684,967	CO	4,967,441	CO	923,667
HC	1,638,356	HC	1,537,184	HC	301,456
NOx	1,569,615	NOx	5,031,223	NOx	841,572
SO2	167,603	SO2	535,935	SO2	89,490
TSP	269,799	TSP	566,021	TSP	99,318
Pb	1,456	Pb	1,029	Pb	212
Kurukshetra		**Rohtak**		**Bhiwani**	
CO	2,445,716	CO	3,006,151	CO	2,685,043
HC	1,052,554	HC	1,105,552	HC	825,643
NOx	1,075,162	NOx	1,627,309	NOx	2,601,639
SO2	104,161	SO2	146,596	SO2	273,929
TSP	184,075	TSP	234,502	TSP	295,979
Pb	920	Pb	1,132	Pb	601
Kaithal		**Faridabad**		**Jind**	
CO	2,207,603	CO	15,952,934	CO	1,765,675
HC	788,483	HC	5,985,430	HC	600,461
NOx	1,750,614	NOx	7,818,737	NOx	1,528,428
SO2	181,259	SO2	685,920	SO2	164,121
TSP	221,762	TSP	1,157,940	TSP	183,025
Pb	570	Pb	6,572	Pb	447
Karnal		**Gurgaon**		**Hissar**	
CO	5,778,634	CO	7,325,212	CO	7,217,249
HC	2,031,885	HC	2,751,693	HC	2,894,964
NOx	4,453,861	NOx	4,562,529	NOx	4,260,351
SO2	499,304	SO2	445,108	SO2	453,167
TSP	561,905	TSP	601,800	TSP	609,299
Pb	1,586	Pb	2,764	Pb	2,469
Sirsa					
CO	3,967,902				
HC	1,462,133				
NOx	1,750,676				
SO2	171,373				
TSP	271,520				
Pb	1,684				

Table 23.3. Estimated emissions (kg/year) in Haryana in transport sector: 1994/95

District	*Emissions*	District	*Emissions*	District	*Emissions*
Ambala		**Panipat**		**Rewari**	
CO	8,580,719	CO	3,415,604	CO	1,707,997
HC	3,429,657	HC	1,396,531	HC	588,941
NOx	3,899,868	NOx	1,892,653	NOx	1,476,822
SO2	436,199	SO2	197,395	SO2	164,496
TSP	628,219	TSP	284,877	TSP	179,597
Pb	3,338	Pb	1,154	Pb	403
Yamunanagar		**Sonipat**		**Mahendragarh**	
CO	4,053,377	CO	5,428,722	CO	994,929
HC	1,826,676	HC	1,689,154	HC	322,747
NOx	1,673,952	NOx	5,489,181	NOx	916,817
SO2	182,231	SO2	592,443	SO2	98,715
TSP	292,231	TSP	617,211	TSP	107,576
Pb	1,632	Pb	1,134	Pb	226
Kurukshetra		**Rohtak**		**Bhiwani**	
CO	2,594,931	CO	3,137,134	CO	2,903,347
HC	1,126,777	HC	1,163,125	HC	892,652
NOx	1,107,355	NOx	1,647,421	NOx	2,825,461
SO2	108,965	SO2	149,982	SO2	301,481
TSP	192,583	TSP	240,723	TSP	320,605
Pb	991	Pb	1,201	Pb	648
Kaithal		**Faridabad**		**Jind**	
CO	2,351,555	CO	16,892,520	CO	1,929,253
HC	836,277	HC	6,470,427	HC	659,298
NOx	1,881,559	NOx	7,806,141	NOx	1,668,947
SO2	197,499	SO2	692,028	SO2	181,565
TSP	237,097	TSP	1,190,901	TSP	199,628
Pb	603	Pb	7,143	Pb	492
Karnal		**Gurgaon**		**Hissar**	
CO	6,275,991	CO	8,097,503	CO	7,881,140
HC	2,185,190	HC	3,150,210	HC	3,193,061
NOx	4,949,440	NOx	4,751,064	NOx	4,592,683
SO2	559,687	SO2	473,101	SO2	496,275
TSP	617,296	TSP	644,760	TSP	659,831
Pb	1,695	Pb	3,164	Pb	2,735
Sirsa					
CO	4,191,207				
HC	1,549,468				
NOx	1,824,919				
SO2	181,252				
TSP	284,625				
Pb	1,791				

Table 23.4. Emissions (kg/year) in Haryana in transport sector: 1995/96

District	*Emissions*	District	*Emissions*	District	*Emissions*
Ambala		**Panipat**		**Rewari**	
CO	9,355,327	CO	3,750,290	CO	1,938,280
HC	3,669,252	HC	1,494,637	HC	642,108
NOx	4,681,717	NOx	2,264,425	NOx	1,793,940
SO2	523,255	SO2	235,956	SO2	199,953
TSP	717,500	TSP	326,105	TSP	211,914
Pb	3,486	Pb	1,206	Pb	421
Yamunanagar		**Sonipat**		**Mahendragarh**	
CO	4,434,050	CO	6,223,675	CO	1,129,041
HC	1,965,464	HC	1,856,280	HC	351,387
NOx	2,000,669	NOx	6,648,747	NOx	1,109,148
SO2	217,006	SO2	718,782	SO2	119,612
TSP	332,018	TSP	732,642	TSP	126,904
Pb	1,728	Pb	1,182	Pb	234
Kurukshetra		**Rohtak**		**Bhiwani**	
CO	2,810,420	CO	3,388,389	CO	3,306,037
HC	1,199,022	HC	1,229,456	HC	975,207
NOx	1,307,839	NOx	1,932,147	NOx	3,415,113
SO2	128,163	SO2	175,333	SO2	365,104
TSP	216,585	TSP	271,929	TSP	379,290
Pb	1,037	Pb	1,241	Pb	671
Kaithal		**Faridabad**		**Jind**	
CO	2,633,784	CO	18,189,059	CO	2,187,006
HC	901,490	HC	6,859,329	HC	719,652
NOx	2,265,717	NOx	9,092,941	NOx	2,020,134
SO2	238,092	SO2	801,010	SO2	220,001
TSP	276,582	TSP	1,337,755	TSP	235,386
Pb	626	Pb	7,427	Pb	515
Karnal		**Gurgaon**		**Hissar**	
CO	7,078,190	CO	8,932,156	CO	8,725,083
HC	2,377,940	HC	3,403,428	HC	3,446,082
NOx	6,015,015	NOx	5,644,667	NOx	5,522,293
SO2	680,461	SO2	561,415	SO2	596,249
TSP	726,958	TSP	742,606	TSP	762,063
Pb	1,770	Pb	3,337	Pb	2,881
Sirsa					
CO	4,514,323				
HC	1,643,360				
NOx	2,149,549				
SO2	213,327				
TSP	321,472				
Pb	1,857				

Table 23.5. Estimated emissions (kg/year) in Himachal in transport sector: 1992/93

District	*Emissions*	District	*Emissions*	District	*Emissions*
Shimla		**Sirmaur**		**Solan**	
CO	1,493,746	CO	1,054,419	CO	2,269,222
HC	313,497	HC	234,049	HC	492,221
NOx	1,705,735	NOx	1,360,258	NOx	2,918,457
SO2	149,691	SO2	107,508	SO2	226,617
TSP	172,085	TSP	137,621	TSP	293,850
Pb	319	Pb	135	Pb	306

Table 23.6 Estimated emissions (kg/year) in Himachal in transport sector: 1993/94

District	*Emissions*	District	*Emissions*	District	*Emissions*
Shimla		**Sirmaur**		**Solan**	
CO	1,554,416	CO	1,108,900	CO	2,382,021
HC	330,006	HC	250,496	HC	522,666
NOx	1,752,300	NOx	1,413,587	NOx	3,038,166
SO2	152,610	SO2	111,211	SO2	234,938
TSP	177,412	TSP	143,619	TSP	306,813
Pb	340	Pb	147	Pb	328

Table 23.7. Estimated emissions (kg/year) in Himachal in transport sector: 1994/95

District	*Emissions*	District	*Emissions*	District	*Emissions*
Shimla		**Sirmaur**		**Solan**	
CO	1,700,215	CO	1,225,202	CO	2,617,003
HC	360,712	HC	277,031	HC	575,669
NOx	2,017,621	NOx	1,593,615	NOx	3,411,467
SO2	178,449	SO2	126,653	SO2	266,094
TSP	203,513	TSP	161,711	TSP	344,177
Pb	322	Pb	146	Pb	322

Table 23.8. Estimated emissions (kg/year) in Himachal from transport: 1995/96

District	*Emissions*	District	*Emissions*	District	*Emissions*
Shimla		**Sirmaur**		**Solan**	
CO	1,920,600	CO	1,362,877	CO	2,912,045
HC	408,569	HC	311,670	HC	641,952
NOx	2,154,420	NOx	1,720,116	NOx	3,691,678
SO2	188,932	SO2	135,996	SO2	286,629
TSP	218,291	TSP	175,246	TSP	373,330
Pb	425	Pb	187	Pb	409

Table 23.9. Estimated emissions (kg/year) in Rajasthan in transport sector: 1992/93

District	Emissions	District	Emissions
Alwar		**Dhaulpur**	
CO	4,083,527	CO	432,626
HC	1,373,459	HC	128,950
NOx	3,398,088	NOx	426,556
SO2	342,377	SO2	47,002
TSP	414,574	TSP	48,111
Pb	1,039	Pb	92
Bharatpur		**Dausa**	
CO	2,644,354	CO	125,983
HC	800,554	HC	47,076
NOx	2,530,322	NOx	69,255
SO2	263,364	SO2	6,765
TSP	289,380	TSP	10,002
Pb	586	Pb	45
Jaipur		**Churu**	
CO	31,551,275	CO	2,045,387
HC	10,276,539	HC	536,717
NOx	24,032,567	NOx	1,736,302
SO2	2,626,919	SO2	192,218
TSP	2,924,043	TSP	186,674
Pb	9,544	Pb	673
Jhunjhunu		**Ganganagar**	
CO	2,157,732	CO	6,231,784
HC	564,013	HC	1,843,083
NOx	2,193,593	NOx	5,233,032
SO2	236,172	SO2	526,740
TSP	233,892	TSP	605,128
Pb	515	Pb	1,806
S. Madhopur			
CO	1,378,444		
HC	370,643		
NOx	1,469,284		
SO2	155,674		
TSP	158,758		
Pb	277		
Sikar			
CO	2,270,381		
HC	619,173		
NOx	2,082,631		
SO2	227,433		
TSP	226,832		
Pb	636		

Table 23.10. Estimated emissions (kg/year) in Rajasthan in transport sector: 1993/94

District	*Emissions*	District	*Emissions*
Alwar		**Dhaulpur**	
CO	4,475,306	CO	474,133
HC	1,505,231	HC	141,322
NOx	3,724,105	NOx	467,480
SO2	375,225	SO2	51,512
TSP	454,349	TSP	52,726
Pb	1,139	Pb	100
Bharatpur		**Dausa**	
CO	2,898,057	CO	138,070
HC	877,360	HC	51,592
NOx	2,773,085	NOx	75,899
SO2	288,632	SO2	7,414
TSP	317,143	TSP	10,962
Pb	642	Pb	50
Jaipur		**Churu**	
CO	34,578,352	CO	2,241,624
HC	11,262,486	HC	588,211
NOx	26,338,288	NOx	1,902,886
SO2	2,878,949	SO2	210,659
TSP	3,204,580	TSP	204,584
Pb	10,459	Pb	738
Jhunjhunu		**Ganganagar**	
CO	2,364,748	CO	6,817,569
HC	618,125	HC	2,012,359
NOx	2,404,050	NOx	5,734,951
SO2	258,831	SO2	577,207
TSP	256,332	TSP	662,455
Pb	564	Pb	1,974
S. Madhopur			
CO	1,510,694		
HC	406,203		
NOx	1,610,249		
SO2	170,609		
TSP	173,989		
Pb	303		
Sikar			
CO	2,488,205		
HC	678,578		
NOx	2,282,442		
SO2	249,254		
TSP	248,595		
Pb	697		

Table 23.11. Estimated emissions (kg/year) in Rajasthan in transport sector: 1994/95

District	*Emissions*	District	*Emissions*
Alwar		**Dhaulpur**	
CO	4,895,843	CO	518,687
HC	1,646,675	HC	154,602
NOx	4,074,053	NOx	511,408
SO2	410,484	SO2	56,352
TSP	497,044	TSP	57,681
Pb	1,246	Pb	110
Bharatpur		**Dausa**	
CO	3,170,382	CO	151,044
HC	959,804	HC	56,441
NOx	3,033,666	NOx	83,031
SO2	315,754	SO2	8,111
TSP	346,945	TSP	11,992
Pb	702	Pb	54
Jaipur		**Churu**	
CO	37,827,618	CO	2,452,265
HC	12,320,802	HC	643,484
NOx	28,813,250	NOx	2,081,697
SO2	3,149,479	SO2	230,455
TSP	3,505,708	TSP	223,809
Pb	11,442	Pb	807
Jhunjhunu			
CO	2,586,959		
HC	676,209		
NOx	2,629,954		
SO2	283,152		
TSP	280,419		
Pb	618		
S. Madhopur			
CO	1,652,651		
HC	444,373		
NOx	1,761,561		
SO2	186,641		
TSP	190,338		
Pb	332		
Sikar			
CO	2,722,017		
HC	742,342		
NOx	2,496,919		
SO2	272,676		
TSP	271,955		
Pb	763		

Table 23.12 Estimated emissions (kg/year) in Rajasthan in transport sector: 1995/96

District	*Emissions*	District	*Emissions*
Alwar		**Dhaulpur**	
CO	5,372,913	CO	569,230
HC	1,807,133	HC	169,667
NOx	4,471,044	NOx	561,242
SO2	450,483	SO2	61,843
TSP	545,478	TSP	63,302
Pb	1,367	Pb	120
Bharatpur		**Dausa**	
CO	3,479,317	CO	165,762
HC	1,053,331	HC	61,940
NOx	3,329,279	NOx	91,122
SO2	346,522	SO2	8,901
TSP	380,752	TSP	13,160
Pb	770	Pb	60
Jaipur		**Churu**	
CO	41,513,690	CO	2,691,224
HC	13,521,389	HC	706,187
NOx	31,620,926	NOx	2,284,545
SO2	3,456,377	SO2	252,911
TSP	3,847,319	TSP	245,617
Pb	12,557	Pb	885
Jhunjhunu		**Ganganagar**	
CO	2,839,042	CO	8,199,489
HC	742,101	HC	2,425,043
NOx	2,886,227	NOx	6,885,378
SO2	310,744	SO2	693,059
TSP	307,744	TSP	796,198
Pb	678	Pb	2,376
S. Madhopur			
CO	1,813,692		
HC	487,674		
NOx	1,933,215		
SO2	204,828		
TSP	208,886		
Pb	364		
Sikar			
CO	2,987,261		
HC	814,679		
NOx	2,740,229		
SO2	299,246		
TSP	298,456		
Pb	837		

Table 23.13. Estimated emissions (kg/year) in Uttar Pradesh in transport sector: 1992/93

District	Emissions	District	Emissions	District	Emissions
Agra		**Ghaziabad**			
CO	10,976,161	CO	3,893,192		
HC	4,272,341	HC	1,159,694		
NOx	3,958,951	NOx	3,277,308		
SO2	423,774	SO2	313,158		
TSP	706,702	TSP	381,934		
Pb	4,350	Pb	1,008		
Aligarh		**Mathura**		**Haridwar**	
CO	3,608,485	CO	2,683,505	CO	2,173,190
HC	1,240,121	HC	953,971	HC	735,999
NOx	3,191,783	NOx	1,810,574	NOx	901,416
SO2	288,798	SO2	159,589	SO2	92,145
TSP	388,187	TSP	239,751	TSP	136,636
Pb	767	Pb	822	Pb	863
Bulandshahr		**Meerut**		**Firozabad**	
CO	3,445,284	CO	8,437,052	CO	1,113,507
HC	901,247	HC	2,615,810	HC	319,658
NOx	3,977,719	NOx	7,156,646	NOx	543,111
SO2	344,083	SO2	650,799	SO2	57,810
TSP	422,491	TSP	844,215	TSP	70,716
Pb	499	Pb	2,115	Pb	425
Dehradun		**Muzaffar Nagar**			
CO	8,580,903	CO	1,386,112		
HC	2,673,362	HC	273,605		
NOx	4,249,795	NOx	1,528,050		
SO2	408,183	SO2	158,383		
TSP	574,375	TSP	154,175		
Pb	3,293	Pb	325		
Etawah		**Sahranpur**		**Etah**	
CO	1,534,266	CO	2,921,554	CO	1,579,746
HC	523,924	HC	1,018,199	HC	430,492
NOx	1,068,686	NOx	2,288,477	NOx	1,610,245
SO2	113,742	SO2	220,704	SO2	148,638
TSP	137,442	TSP	288,534	TSP	175,818
Pb	425	Pb	736	Pb	322

Table 23.14. Estimated emissions (kg/year) in Uttar Pradesh in transport sector: 1993/94

District	*Emissions*	District	*Emissions*	District	*Emissions*
Agra		**Ghaziabad**			
CO	12,039,675	CO	4,270,416		
HC	4,686,301	HC	1,272,060		
NOx	4,342,546	NOx	3,594,856		
SO2	464,835	SO2	343,501		
TSP	775,177	TSP	418,941		
Pb	4,772	Pb	1,106		
Aligarh		**Mathura**		**Haridwar**	
CO	3,958,122	CO	2,943,518	CO	2,383,757
HC	1,360,280	HC	1,046,404	HC	807,312
NOx	3,501,045	NOx	1,986,007	NOx	988,757
SO2	316,781	SO2	175,052	SO2	101,073
TSP	425,799	TSP	262,981	TSP	149,875
Pb	842	Pb	901	Pb	947
Bulandshahr		**Meerut**		**Firozabad**	
CO	3,779,108	CO	9,254,544	CO	1,221,399
HC	988,572	HC	2,869,264	HC	350,630
NOx	4,363,133	NOx	7,850,075	NOx	595,735
SO2	377,422	SO2	713,857	SO2	63,412
TSP	463,428	TSP	926,013	TSP	77,567
Pb	547	Pb	2,320	Pb	466
Dehradun		**Muzaffar Nagar**			
CO	9,412,333	CO	1,520,417		
HC	2,932,393	HC	300,116		
NOx	4,661,571	NOx	1,676,108		
SO2	447,734	SO2	173,730		
TSP	630,028	TSP	169,113		
Pb	3,612	Pb	356		
Etawah		**Sahranpur**		**Etah**	
CO	1,682,926	CO	3,204,632	CO	1,732,812
HC	574,689	HC	1,116,856	HC	472,203
NOx	1,172,234	NOx	2,510,214	NOx	1,766,267
SO2	124,763	SO2	242,088	SO2	163,040
TSP	150,759	TSP	316,491	TSP	192,853
Pb	466	Pb	808	Pb	353

Table 23.15. Estimated emissions (kg/year) in Uttar Pradesh in transport sector: 1994/95

District	Emissions	District	Emissions	District	Emissions
Agra		**Ghaziabad**			
CO	12,496,900	CO	4,432,591		
HC	4,864,271	HC	1,320,368		
NOx	4,507,461	NOx	3,731,376		
SO2	482,488	SO2	356,546		
TSP	804,615	TSP	434,850		
Pb	4,953	Pb	1,148		
Aligarh		**Mathura**		**Haridwar**	
CO	4,108,438	CO	3,055,303	CO	2,474,284
HC	1,411,939	HC	1,086,143	HC	837,971
NOx	3,634,002	NOx	2,061,428	NOx	1,026,307
SO2	328,811	SO2	181,700	SO2	104,912
TSP	441,970	TSP	272,968	TSP	155,567
Pb	874	Pb	936	Pb	983
Bulandshahr		**Meerut**		**Firozabad**	
CO	3,922,626	CO	9,606,000	CO	1,267,783
HC	1,026,114	HC	2,978,229	HC	363,946
NOx	4,528,829	NOx	8,148,194	NOx	618,359
SO2	391,756	SO2	740,967	SO2	65,820
TSP	481,027	TSP	961,180	TSP	80,513
Pb	568	Pb	2,408	Pb	484
Dehradun		**Muzaffar Nagar**			
CO	9,769,781	CO	1,578,157		
HC	3,043,755	HC	311,513		
NOx	4,838,602	NOx	1,739,760		
SO2	464,737	SO2	180,327		
TSP	653,955	TSP	175,535		
Pb	3,750	Pb	370		
Etawah		**Sahranpur**		**Etah**	
CO	1,746,837	CO	3,326,333	CO	1,798,619
HC	596,514	HC	1,159,270	HC	490,136
NOx	1,216,752	NOx	2,605,544	NOx	1,833,344
SO2	129,501	SO2	251,282	SO2	169,232
TSP	156,484	TSP	328,510	TSP	200,177
Pb	484	Pb	839	Pb	367

Table 23.16. Estimated emissions (kg/year) in Uttar Pradesh in transport sector: 1995/96

District	*Emissions*	District	*Emissions*	District	*Emissions*
Agra		**Ghaziabad**			
CO	12,984,911	CO	4,605,686		
HC	5,054,223	HC	1,371,929		
NOx	4,683,480	NOx	3,877,088		
SO2	501,329	SO2	370,470		
TSP	836,036	TSP	451,832		
Pb	5,147	Pb	1,193		
Aligarh		**Mathura**		**Haridwar**	
CO	4,268,875	CO	3,174,614	CO	2,570,906
HC	1,467,076	HC	1,128,558	HC	870,694
NOx	3,775,912	NOx	2,141,928	NOx	1,066,384
SO2	341,651	SO2	188,795	SO2	109,008
TSP	459,229	TSP	283,628	TSP	161,642
Pb	908	Pb	972	Pb	1,021
Bulandshahr		**Meerut**		**Firozabad**	
CO	4,075,807	CO	9,981,119	CO	1,317,291
HC	1,066,185	HC	3,094,531	HC	378,158
NOx	4,705,682	NOx	8,466,385	NOx	642,506
SO2	407,054	SO2	769,902	SO2	68,390
TSP	499,811	TSP	998,715	TSP	83,657
Pb	590	Pb	2,502	Pb	503
Dehradun		**Muzaffar Nagar**			
CO	10,151,296	CO	1,639,785		
HC	3,162,615	HC	323,678		
NOx	5,027,552	NOx	1,807,699		
SO2	482,885	SO2	187,369		
TSP	679,492	TSP	182,390		
Pb	3,896	Pb	384		
Etawah		**Sahranpur**		**Etah**	
CO	1,815,052	CO	3,456,228	CO	1,868,856
HC	619,808	HC	1,204,540	HC	509,276
NOx	1,264,267	NOx	2,707,292	NOx	1,904,937
SO2	134,559	SO2	261,095	SO2	175,841
TSP	162,595	TSP	341,338	TSP	207,994
Pb	503	Pb	871	Pb	381

Table 23.17 Estimated emissions (kg/year) in Delhi in transport sector: 1992/93 to 1994/95

Pollutant	*1992/93*	*1993/94*	*1994/95*
CO	123,728,594	128,869,945	135,362,196
HC	52,003,740	53,374,900	55,320,535
NOx	45,588,379	51,157,153	54,063,980
SO2	3,279,221	3,683,121	3,900,481
TSP	8,425,927	9,317,102	9,846,813
Pb	76,828	79,372	86,352

Table 23.18. Estimated emissions (tonnes/year) from domestic sector in Yamuna sub-basin: 1992/93

District	*Emissions*	District	*Emissions*	District	*Emissions*
Ambala		**Bhiwani**		**Bharatpur**	
SPM	1,447	SPM	1,321	SPM	3,673
CO	9,894	CO	9,950	CO	25,882
SO2	0	SO2	0	SO2	0
NOx	54	NOx	13	NOx	16
Kurukshetra		**Hissar**		**Jaipur**	
SPM	1,466	SPM	1,555	SPM	4,316
CO	9,533	CO	12,63[illegible]	CO	36,549
SO2	0	SO2	0	SO2	0
NOx	17	NOx	31	NOx	124
Karnal		**Sirsa**		**Jhunjunu**	
SPM	1,821	SPM	661	SPM	1,136
CO	11,969	CO	5,694	CO	10,128
SO2	0	SO2	0	SO2	0
NOx	26	NOx	13	NOx	14
Jind		**Rewari**		**S. Madhopur**	
SPM	1,523	SPM	669	SPM	4,075
CO	10,583	CO	5,027	CO	29,119
SO2	0	SO2	0	SO2	0
NOx	11	NOx	7	NOx	12
Sonipat		**Kaithal**		**Sikar**	
SPM	1,050	SPM	1,974	SPM	1,794
CO	7,396	CO	12,923	CO	15,906
SO2	0	SO2	0	SO2	0
NOx	19	NOx	6	NOx	15
Panipat		**Yamunanagar**		**Dhaulpur**	
SPM	1,356	SPM	1,218	SPM	1,120
CO	9,222	CO	8,452	CO	8,694
SO2	0	SO2	0	SO2	0
NOx	22	NOx	24	NOx	5
Rohtak		**Shimla**		**Churu**	
SPM	2,879	SPM	331	SPM	1,237
CO	19,957	CO	3,005	CO	10,708
SO2	0	SO2	0	SO2	0
NOx	41	NOx	13	NOx	12
Faridabad		**Sirmaur**		**Ganganagar**	
SPM	1,569	SPM	232	SPM	1,903
CO	11,596	CO	2,094	CO	16,672
SO2	0	SO2	0	SO2	0
NOx	50	NOx	4	NOx	21
Gurgaon		**Solan**		**Agra**	
SPM	1,786	SPM	211	SPM	4,231
CO	12,337	CO	1,910	CO	29,052
SO2	0	SO2	0	SO2	0
NOx	27	NOx	6	NOx	67
Mahendragarh		**Alwar**		**Aligarh**	
SPM	575	SPM	3,477	SPM	7,524
CO	4,805	CO	26,750	CO	50,547
SO2	0	SO2	0	SO2	0
NOx	5	NOx	23	NOx	35

Table 23.18 continued. Estimated emissions (tonnes/year) from domestic sector in Yamuna sub-basin: 1992/93

District	Emissions	District	Emissions
Bulandshahr		**Firozabad**	
SPM	8,186	SPM	2,624
CO	53,503	CO	17,292
SO2	0	SO2	0
NOx	25	NOx	18
Dehradun		**Tehri Garhwal**	
SPM	389	SPM	368
CO	3,551	CO	3,292
SO2	0	SO2	0
NOx	65	NOx	4
Etawah		**Etah**	
SPM	2,617	SPM	4,966
CO	20,719	CO	34,087
SO2	0	SO2	0
NOx	12	NOx	13
Ghaziabad		**Mainpuri**	
SPM	7,097	SPM	3,245
CO	44,862	CO	21,981
SO2	0	SO2	0
NOx	91	NOx	8
Mathura		**Delhi**	
SPM	3,193	SPM	3,278
CO	22,324	CO	25,845
SO2	0	SO2	0
NOx	23	NOx	844
Meerut			
SPM	10,728		
CO	67,924		
SO2	0		
NOx	83		
Muzaffar Nagar			
SPM	9,495		
CO	60,924		
SO2	0		
NOx	35		
Sahranpur			
SPM	5,052		
CO	34,002		
SO2	0		
NOx	40		
Uttarkashi			
SPM	440		
CO	3,003		
SO2	0		
NOx	1		
Haridwar			
SPM	1,789		
CO	12,503		
SO2	0		
NOx	35		

Table 23.19 Estimated emissions (tonnes/year) from domestic sector in Yamuna sub-basin: 1993/94

District	*Emissions*	District	*Emissions*	District	*Emissions*
Ambala		**Bhiwani**		**Bharatpur**	
SPM	1,474	SPM	1,345	SPM	3,741
CO	10,076	CO	10,133	CO	26,357
SO2	0	SO2	0	SO2	0
NOx	55	NOx	13	NOx	17
Kurukshetra		**Hissar**		**Jaipur**	
SPM	1,493	SPM	1,584	SPM	4,395
CO	9,707	CO	12,869	CO	37,219
SO2	0	SO2	0	SO2	0
NOx	17	NOx	32	NOx	127
Karnal		**Sirsa**		**Jhunjhunu**	
SPM	1,854	SPM	673	SPM	1,157
CO	12,189	CO	5,798	CO	10,314
SO2	0	SO2	0	SO2	0
NOx	27	NOx	13	NOx	14
Jind		**Rewari**		**S. Madhopur**	
SPM	1,551	SPM	682	SPM	4,149
CO	10,777	CO	5,119	CO	29,653
SO2	0	SO2	0	SO2	0
NOx	11	NOx	7	NOx	12
Sonipat		**Kaithal**		**Sikar**	
SPM	1,070	SPM	2,010	SPM	1,826
CO	7,532	CO	13,160	CO	16,198
SO2	0	SO2	0	SO2	0
NOx	20	NOx	7	NOx	15
Panipat		**Yamunanagar**		**Dhaulpur**	
SPM	1,381	SPM	1,240	SPM	1,140
CO	9,391	CO	8,607	CO	8,854
SO2	0	SO2	0	SO2	0
NOx	22	NOx	25	NOx	5
Rohtak		**Shimla**		**Churu**	
SPM	2,932	SPM	337	SPM	1,260
CO	20,323	CO	3,061	CO	10,905
SO2	0	SO2	0	SO2	0
NOx	41	NOx	14	NOx	12
Faridabad		**Sirmaur**		**Ganganagar**	
SPM	1,598	SPM	236	SPM	1,937
CO	11,809	CO	2,133	CO	
SO2	0	SO2	0	SO2	
NOx	51	NOx	4	NOx	
Gurgaon		**Solan**		**Agra**	
SPM	1,819	SPM	214	SPM	4,309
CO	12,564	CO	1,945	CO	29,585
SO2	0	SO2	0	SO2	0
NOx	28	NOx	7	NOx	68
Mahendragarh		**Alwar**		**Aligarh**	
SPM	586	SPM	3,541	SPM	7,662
CO	4,894	CO	27,241	CO	51,475
SO2	0	SO2	0	SO2	0
NOx	5	NOx	23	NOx	36

continued...

Table 23.19 continued. Estimated emissions (tonnes/year) from domestic sector in Yamuna sub-basin: 1993/94

District	Emissions	District	Emissions
Bulandshahr		**Firozabad**	
SPM	8,336	SPM	2,672
CO	54,484	CO	17,610
SO2	0	SO2	0
NOx	26	NOx	18
Dehradun		**Tehri Garhwal**	
SPM	397	SPM	375
CO	3,616	CO	3,352
SO2	0	SO2	0
NOx	67	NOx	4
Etawah		**Etah**	
SPM	2,665	SPM	5,058
CO	21,099	CO	34,712
SO2	0	SO2	0
NOx	12	NOx	14
Ghaziabad		**Mainpuri**	
SPM	7,228	SPM	3,305
CO	45,685	CO	22,384
SO2	0	SO2	0
NOx	93	NOx	8
Mathura		**Delhi**	
SPM	3,251	SPM	3,338
CO	22,734	CO	26,319
SO2	0	SO2	0
NOx	23	NOx	859
Meerut			
SPM	10,925		
CO	69,170		
SO2	0		
NOx	84		
Muzaffar Nagar			
SPM	9,669		
CO	62,042		
SO2	0		
NOx	35		
Sahranpur			
SPM	5,145		
CO	34,626		
SO2	0		
NOx	40		
Uttarkashi			
SPM	448		
CO	3,058		
SO2	0		
NOx	1		
Haridwar			
SPM	1,822		
CO	12,733		
SO2	0		
NOx	36		

Table 23.20. Estimated emissions (tonnes/year) from domestic sector in Yamuna sub-basin: 1994/95

District	*Emissions*	District	*Emissions*	District	*Emissions*
Ambala		**Bhiwani**		**Bharatpur**	
SPM	1,500	SPM	1,369	SPM	3,808
CO	10,257	CO	10,315	CO	26,832
SO2	0	SO2	0	SO2	0
NOx	56	NOx	13	NOx	17
Kurukshetra		**Hissar**		**Jaipur**	
SPM	1,519	SPM	1,612	SPM	4,474
CO	9,882	CO	13,100	CO	37,890
SO2	0	SO2	0	SO2	0
NOx	17	NOx	32	NOx	129
Karnal		**Sirsa**		**Jhunjhunu**	
SPM	1,888	SPM	686	SPM	1,177
CO	12,408	CO	5,903	CO	10,500
SO2	0	SO2	0	SO2	0
NOx	27	NOx	13	NOx	14
Jind		**Rewari**		**S. Madhopur**	
SPM	1,579	SPM	694	SPM	4,224
CO	10,971	CO	5,212	CO	30,188
SO2	0	SO2	0	SO2	0
NOx	11	NOx	8	NOx	12
Sonipat		**Kaithal**		**Sikar**	
SPM	1,089	SPM	2,046	SPM	1,859
CO	7,668	CO	13,397	CO	16,490
SO2	0	SO2	0	SO2	0
NOx	20	NOx	7	NOx	16
Panipat		**Yamunanagar**		**Dhaulpur**	
SPM	1,406	SPM	1,263	SPM	1,161
CO	9,560	CO	8,762	CO	9,013
SO2	0	SO2	0	SO2	0
NOx	23	NOx	25	NOx	5
Rohtak		**Shimla**		**Churu**	
SPM	2,985	SPM	343	SPM	1,283
CO	20,689	CO	3,116	CO	11,101
SO2	0	SO2	0	SO2	0
NOx	42	NOx	14	NOx	13
Faridabad		**Sirmaur**		**Ganganagar**	
SPM	1,627	SPM	241	SPM	1,972
CO	12,021	CO	2,171	CO	17,284
SO2	0	SO2	0	SO2	0
NOx	52	NOx	4	NOx	21
Gurgaon		**Solan**		**Agra**	
SPM	1,852	SPM	218	SPM	4,387
CO	12,790	CO	1,980	CO	30,118
SO2	0	SO2	0	SO2	0
NOx	28	NOx	7	NOx	70
Mahendragarh		**Alwar**		**Aligarh**	
SPM	596	SPM	3,605	SPM	7,800
CO	4,982	CO	27,732	CO	52,402
SO2	0	SO2	0	SO2	0
NOx	5	NOx	24	NOx	37

continued...

Table 23.20 continued. Estimated emissions (tonnes/year) from domestic sector in Yamuna sub-basin: 1994/95

District	Emissions	District	Emissions
Bulandshahr		**Firozabad**	
SPM	8,486	SPM	2,720
CO	55,466	CO	17,927
SO2	0	SO2	0
NOx	26	NOx	19
Dehradun		**Tehri Garhwal**	
SPM	404	SPM	382
CO	3,682	CO	3,413
SO2	0	SO2	0
NOx	68	NOx	4
Etawah		**Etah**	
SPM	2,713	SPM	5,149
CO	21,480	CO	35,338
SO2	0	SO2	0
NOx	12	NOx	14
Ghaziabad		**Mainpuri**	
SPM	7,358	SPM	3,364
CO	46,508	CO	22,787
SO2	0	SO2	0
NOx	95	NOx	8
Mathura		**Delhi**	
SPM	3,310	SPM	3,398
CO	23,143	CO	26,793
SO2	0	SO2	0
NOx	23	NOx	874
Meerut			
SPM	11,122		
CO	70,417		
SO2	0		
NOx	86		
Muzaffar Nagar			
SPM	9,844		
CO	63,160		
SO2	0		
NOx	36		
Sahranpur			
SPM	5,237		
CO	35,250		
SO2	0		
NOx	41		
Uttarkashi			
SPM	456		
CO	3,113		
SO2	0		
NOx	1		
Haridwar			
SPM	1,855		
CO	12,962		
SO2	0		
NOx	36		

Table 23.21 Estimated emissions (tonnes/year) from domestic sector in Yamuna sub-basin: 1995/96

District	*Emissions*	District	*Emissions*	District	*Emissions*
Ambala	1,528	**Bhiwani**		**Bharatpur**	
SPM	10,450	SPM	1,395	SPM	3,880
CO	0	CO	10,509	CO	27,337
SO2	57	SO2	0	SO2	0
NOx	0	NOx	14	NOx	17
Kurukshetra		**Hissar**		**Jaipur**	
SPM	1,548	SPM	1,643	SPM	4,558
CO	10,068	CO	13,347	CO	38,603
SO2	0	SO2	0	SO2	0
NOx	18	NOx	33	NOx	131
Karnal		**Sirsa**		**Jhunjhunu**	
SPM	1,923	SPM	698	SPM	1,200
CO	12,642	CO	6,014	CO	10,697
SO2	0	SO2	0	SO2	0
NOx	28	NOx	14	NOx	14
Jind		**Rewari**		**S. Madhopur**	
SPM	1,608	SPM	707	SPM	4,304
CO	11,177	CO	5,310	CO	30,755
SO2	0	SO2	0	SO2	0
NOx	11	NOx	8	NOx	13
Sonipat		**Kaithal**		**Sikar**	
SPM	1,109	SPM	2,085	SPM	1,894
CO	7,812	CO	13,649	CO	16,800
SO2	0	SO2	0	SO2	0
NOx	20	NOx	7	NOx	16
Panipat		**Yamunanagar**		**Dhaulpur**	
SPM	1,432	SPM	1,287	SPM	1,183
CO	9,740	CO	8,927	CO	9,183
SO2	0	SO2	0	SO2	0
NOx	23	NOx	26	NOx	5
Rohtak		**Shimla**		**Churu**	
SPM	3,041	SPM	349	SPM	1,307
CO	21,078	CO	3,174	CO	11,310
SO2	0	SO2	0	SO2	0
NOx	43	NOx	14	NOx	13
Faridabad		**Sirmaur**		**Ganganagar**	
SPM	1,657	SPM	245	SPM	2,009
CO	12,248	CO	2,212	CO	17,609
SO2	0	SO2	0	SO2	0
NOx	53	NOx	4	NOx	22
Gurgaon		**Solan**		**Agra**	
SPM	1,887	SPM	222	SPM	4,469
CO	13,030	CO	2,017	CO	30,685
SO2	0	SO2	0	SO2	0
NOx	29	NOx	7	NOx	71
Mahendragarh		**Alwar**		**Aligarh**	
SPM	608	SPM	3,672	SPM	7,947
CO	5,076	CO	28,253	CO	53,388
SO2	0	SO2	0	SO2	0
NOx	6	NOx	24	NOx	37

continued...

Table 23.21 continued. Estimated emissions (tonnes/year from domestic sector in Yamuna sub-basin: 1995/96

District	Emissions	District	Emissions
Bulandshahr		**Firozabad**	
SPM	8,646	SPM	2,772
CO	56,509	CO	18,264
SO2	0	SO2	0
NOx	27	NOx	19
Dehradun		**Tehri Garhwal**	
SPM	411	SPM	389
CO	3,751	CO	3,477
SO2	0	SO2	0
NOx	69	NOx	5
Etawah		**Etah**	
SPM	2,764	SPM	5,245
CO	21,884	CO	36,002
SO2	0	SO2	0
NOx	12	NOx	14
Ghaziabad		**Mainpuri**	
SPM	7,496	SPM	3,428
CO	47,383	CO	23,216
SO2	0	SO2	0
NOx	96	NOx	9
Mathura		**Delhi**	
SPM	3,372	SPM	3,462
CO	23,578	CO	27,297
SO2	0	SO2	0
NOx	24	NOx	891
Meerut			
SPM	11,331		
CO	71,741		
SO2	0		
NOx	88		
Muzaffar Nagar			
SPM	10,029		
CO	64,348		
SO2	0		
NOx	37		
Sahranpur			
SPM	5,336		
CO	35,913		
SO2	0		
NOx	42		
Uttarkashi			
SPM	465		
CO	3,171		
SO2	0		
NOx	1		
Haridwar			
SPM	1,889		
CO	13,206		
SO2	0		
NOx	37		

Power

Table 23.22 Emissions of air pollutants from power plants in Yamuna sub-basin (tonnes/year): 1992/93

Power plant	SO2	CO	HC	NOx	SPM
Steam thermal					
Badarpur 1-5	33140	3993	1996	10541	63884
I.P.Station	9389	1131	566	2986	18099
Rajghat 1-2	3970	478	239	1263	7653
Faridabad 1-3	5936	715	358	1888	11443
Panipat 1-5	18373	2214	1107	,5844	35418
Harduaganj B 1-7	7950	958	479	2529	15324
Harduaganj A	0	0	0	0	0
Dadri (NCR) th 1-4	2689	324	162	855	5184
Gas thermal					
Dadri GT	4	121	7	1247	36
Auraiya GT	9	260	15	2679	77
Desu GT	3	79	5	814	23

Table 23.23 Emissions of air pollutants from power plants in Yamuna sub-basin (tonnes/year): 1993/94

Power plant	SO2	CO	HC	NOx	SPM
Steam thermal					
Badarpur 1-5	32185	3878	1939	10237	62043
I.P.Station	7797	939	470	2480	15030
Rajghat 1-2	4350	524	262	1384	8386
Faridabad 1-3	4920	593	296	1565	9485
Panipat 1-5	14777	1780	890	4700	28486
Harduaganj B 1-7	8559	1031	516	2722	16500
Harduaganj A	0	0	0	0	0
Dadri (NCR) th 1-4	9251	1115	557	2942	17833
Gas thermal					
Dadri GT	4	110	6	1134	32
Auraiya GT	10	281	17	2888	83
Desu GT	3	77	5	793	23

Table 23.24 Emissions of air pollutants from power plants in Yamuna sub-basin (tonnes/year): 1994/95

Power plant	SO2	CO	HC	NOx	SPM
Steam thermal					
Badarpur 1-5	32612	3929	1965	10373	62866
I P.Station	7566	912	456	2406	14584
Rajghat 1-2	5850	705	352	1861	11276
Faridabad 1-3	5219	629	314	1660	10061
Panipat 1-5	16596	1999	1000	5279	31992
Harduaganj B 1-7	6366	767	384	2025	12273
Harduaganj A	0	0	0	0	0
Dadri (NCR) th 1-4	15340	1848	924	4879	29572
Gas thermal					
Dadri GT	7	187	11	1929	55
Auraiya GT	10	292	17	3006	86
Desu GT	2	56	3	581	17

Table 23.25. Emissions of TSP (tonnes/year) from sugar mills in the Yamuna sub-basin: 1994

Name	*Location*	*State*	*District*	*TSP emission(tonnes/ year)*
Up state sugar corp	Doiwala	UP	Dehradun	8250
Rai Bahadur Narain Singh Sugar Mills	Haridwar	UP	Haridwar	11550
Mahalakshmi	Haridwar	UP	Haridwar	9900
Gangeshwar	Deoband	UP	Sahranpur	33000
Kisan Co-operative	Sarsawa	UP	Sahranpur	8250
UP State Sugar Corporation	Sahranpur	UP	Sahranpur	8250
Kisan Sahakari Chini	Nanauta	UP	Sahranpur	8250
Mansurpur	Mansurpur	UP	Muzaffar Nagar	8250
Triveni Engineering Works	Khatauli	UP	Muzaffar Nagar	33000
UP State sugar	Muzaffar Nagar	UP	Muzaffar Nagar	4290
Upper Doab	Shamli	UP	Muzaffar Nagar	12573
Ganga Kisan Sahakari	Morna	UP	Muzaffar Nagar	8250
Titatwi Sugar	Titawi	UP	Muzaffar Nagar	9900
UP State sugar	Sakhoti-tanda	UP	Meerut	4950
Daurala	Daurala	UP	Meerut	21450
UP State sugar	Meerut	UP	Meerut	4022 7
UP State sugar	Mohiuddinpur	UP	Meerut	8250
Mawana	Mawana	UP	Meerut	26400
Bagpat	Bagpat	UP	Meerut	8250
Ramala Sahakari		UP	Meerut	4125
Modi Sugar Mills	Modinagar	UP	Ghaziabad	8250
Simbhaoli	Simbhaoli	UP	Ghaziabad	16500
UP State sugar	Panninagar	UP	Bulandshahr	4125
Kisan Sahakari	Anoopshahr	UP	Bulandshahr	8250
Agauta	Agauta	UP	Bulandshahr	8250
Saraswati	Yamunanagar	UP	Yamunanagar	26400
Panipat	Panipat	Haryana	Panipat	5940
Karnal Co-op	Karnal	Haryana	Karnal	4125
Haryana Co-op	Rohtak	Haryana	Rohtak	5775
Meham	Meham	Haryana	Rohtak	8250
Sonipat Co-op	Sonipat	Haryana	Sonipat	4125
Jind	Jind	Haryana	Jind	4125
Palwal	Palwal	Haryana	Faridabad	4125
Shahabad	Shahabad	Haryana	Kurukshetra	4125
Kaithal	Kaithal	Haryana	Kurukshetra	8250
Bhuna	Bhuna	Haryana	Hisar	8250
Rajasthan state Ganganagar	Ganganagar	Rajasthan	Ganganagar	3300

Table 23.26. Emissions of TSP (t/y) by urea plant in the Yamuna sub-basin: 1994

Plant	Location	State	District	Production('00	TSP(t/y)	SO2(t)	NO2(t)
NFL	Panipat	Haryana	Panipat	455	4550	319	910

Table 23.27. Emissions of TSP (t/y) by super phosphate plants in the Yamuna sub-basin:1994

Plant	Location	State	District	Production('00	TSP(t/y)	SO2(t)	NO2(t)
Bharat chemicals & Fertilizers	Alwar	Rajasthan	Alwar	30.4	23		
Hindustan Copper	Khetri	Rajasthan	Jhunjhunu	30.4	23		
India Ceroils	Dharuhera	Haryana	Rewari	38.0	29		
Jayshree chemicals	Pataudi	Haryana	Gurgaon	29 0	22		
Oriental carbon and chemical	Dharuhera	Haryana	Rewari	44.1	34		
Girraj Fertilizer and chemicals	Shikohabad	UP	Shikohabad	8 3	6		
Natraj organics	Muzhafar nagar	UP	Muzhafar naga	11.3	9		
Neera chemical & Fertilizers	Ghaziabad	UP	Ghaziabad	27.6	21		
Vijay Fertilizers	Ghaziabad	UP	Ghaziabad	23 4	18		

Table 23.28. Emissions of TSP from cement plants in the Yamuna sub-basin: 1994

Name	*Location*	*State*	*District*	*TSP emission(t/y)*
ACC ltd(Bhupendra)	surajpur	Haryana	Ambala	2588
CCI ltd	Charkhi dadri	Haryana	Bhiwani	1097
CCI ltd	Rajban	HP	Sirmaur	1275
Jaipur udyog ltd	Sawai madhopur	Rajasthan	Sawai madhopur	6375

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